

Editorial

This year's issue of *Phelsuma* contains ecological and taxonomic papers on a wide range organisms, although plants are conspicuous by their absence. The animal studies featured indicate the notable increase in ecological, taxonomic and conservation assessment research in the region in recent years.

The increase in research in the Western Indian Ocean means that synthesis of new information is becoming increasingly important. For Madagascar the 2003 volume 'The Natural History of Madagascar' (Goodman & Benstead; University of Chicago Press) is the definitive synthesis and is likely to remain so for many years. Seychelles remains dependant on the old and out-of-print 1984 'Biogeography and Ecology of the Seychelles Islands' (edited by D.R. Stoddart; Dr. W. Junk Publishers, The Hague). Until this year no synthesis volume was available for the Mascarenes. This has now been rectified by the publication of 'Lost Land of the Dodo' by Anthony Cheke and Julian Hume (T&AD Poyser, London). This book provides a comprehensive evaluation of the decline in vertebrate populations of the Mascarene islands. This in itself is a dramatic and deeply depressing story, but the book puts these declines in the context of changes in the ecosystems of the islands. It is a fantastically detailed work and has taken many years of painstaking historical research. Even though these islands are famous for their remarkable extinct species such as the dodo and there are comparatively abundant subfossil deposits, reconstructing the islands' past depends on interpreting scattered documents. Many of the interpretations made in the past have been disputed but Cheke and Hume provide a very closely argued interpretation which is very convincing. At 464 pages this is a remarkable work of scholarship, and as it is hardly likely to be a mainstream popular publication is perhaps even more remarkable in having found a publisher. The publishers are to be congratulated for standing out in this day of fast returns cut-price publications. Although the 'Lost Land of the Dodo' will remain one of the most significant publications on the Western Indian Ocean there remain two enormous gaps - comprehensive accounts of the past and present status of the flora and the invertebrates of the Mascarenes.

J. Gerlach
Editor

Chairman's Report

Two important alliances were strengthened this year, the first with Conservation International and the second with Labriz Silhouette, the hotel which opened at the end of 2006. In recent years we have received project funding from Conservation International (Madagascar) in support of the Indian Ocean Biodiversity Assessment and the subsequent publication of the monograph on Seychelles Lepidoptera. This year, CI (Madagascar) funded our ongoing Seychelles sheath-tailed bat conservation project and in June Harison Randrianasolo and Zo Rakotobe came to Silhouette on a project site inspection. Their enthusiasm and interest in the future prospect of a Silhouette National Park was an immense morale boost for us.

Our partnership with Labriz Silhouette has developed since the new resident manager, Vinesh Gupta, arrived on the island. During the turtle nesting season the hotel staff produced a number of small sign posts alerting guests to the presence of turtle nests in front of the guest rooms. They also made a light excluding box to our design which is used to prevent hatchlings seeing and being attracted to the hotel lights. This year only three hatchlings were found in the hotel grounds, compared with 200 last year. As a follow-up to this first cooperative venture, Labriz have made some of their gardening staff available to us so that we can make a greater impact on the forest Rehabilitation Project. On Environment Day (5th June) many of the senior staff joined us and we worked with their gardening team to clean up a new area between the Anse Lascars trail and the forest area that has already been restored.

Two further volumes of the monographic series resulting from studies carried out subsequent to the Indian Ocean Biodiversity Assessment were published this year. «« Terrestrial and Freshwater Vertebrates of the Seychelles Islands » was edited by Justin Gerach, and « Orthopteroidea of the Seychelles Islands » by Justin Gerlach and Fabian Haas which describes all the crickets, cockroaches, earwigs and termites recorded on the islands. Forthcoming volumes cover the flies, the spiders and the beetles and are expected to be published within the next year. The spider monograph will be dedicated to the late Dr. Michael Saaristo who was the world expert on Seychelles spiders.

We wish to thank the following donors and organisations for their support and encouragement during the year :

Conservation International (Madagascar)	project funding
Labriz Silhouette	logistical and project support
Islands Development Company	secondment of one worker to the tortoise project
Peter Kistler	publication funding
Rick Watson	project funding
Guy Van Heygen	donation of terrapin food
ExoTerra	donation of terrapin food and water pumps
Pool & Patel	honorary auditors

Volunteers

Volunteers have always been a great help to us and we wish to thank the following persons for their help this year. John Pemberton monitored the released tortoises at Grande Barbe in June. The Earthwatch teams were on Silhouette in June and July and assisted with various projects that were not part of their research project. Guy Van Heygen watched over the projects while we were away. Kees Van Unens monitored the released tortoises and the nesting turtles on Grande Barbe in November. Finally, the Sussex University students took time off during their field course to help with various projects.

Scientific and other visitors

Dr. Jim Juvik visited Silhouette in June bringing with him monitoring equipment for the tortoise project. The Earthwatch programme carried out coastal and marine research in July and August.

Bernard Devaux from the Village des Tortues, Gofarou, France visited the tortoise and terrapin projects in July.

Selby Remie from the Ministry of Environment accompanied a team from the Forestry division on an inspection treatment visit dealing with Takamaka wilt. Linda Verherck from North Island came with volunteers from the Island Conservation Society to familiarise themselves with the terrapin project.

Guy Van Heygen looked after the projects in August/September and Rick Watson, sponsor of the Silhouette Conservation Project visited in September.

Also in September Mary Stravens and Herve Barois of ICS, came to discuss the Environmental Impact Assessment for the proposed road over Silhouette.

In November, the surveyor, the engineer and the contractor for the proposed road visited the island and were taken up part of the route to discuss some possible mitigation measures. In December two French volunteers from ICS visited the terrapin project.

Dr. Antoine Cadi and a group of tortoise specialists from the University of Paris visited the tortoise project in February prior to their trip to Aldabra. Also in February Dr. Bruno Santerre spent several weeks researching vegetation structure on Silhouette and Drs. Christopher Kaiser and Nancy Bunbury visited the NPTS information centre to learn about ongoing projects.

Overseas visits and meetings

On 14-17th January 2008 Justin Gerlach was one of the 80 participants invited to attend the meeting 'Turtles on the Brink in Madagascar', organised by the IUCN/Species Survival Commission Tortoise and Freshwater Specialist Group and Madagascar's Ministère de l'Environnement, des Eaux et Forêts et du Tourisme, Wildlife Conservation Society, Conservation International and Durrell Wildlife Conservation Trust. This meeting was held to discuss the conservation needs of the Western Indian Ocean tortoises and terrapins and to devise mechanisms for the conservation of Madagascar's highly threatened tortoises. The 'Vision Sokatra Gasy' or Madagascar Turtle Vision should be a big step forward in conserving the most threatened tortoises in the world.

Seychelles Giant tortoise Conservation Project

Last year I reported a decline in general fertility of the tortoises caused by the continual disturbance from passing vehicles on their way to dump food waste in the forest. This paled into insignificance this year with the construction of 5 concrete buildings on the beach opposite the enclosures. We and the tortoises have had a nerve-shattering year with the incessant noise of screaming machinery and decrepit vehicles spewing diesel fumes into the house and over the tortoise enclosures. From the 50 eggs Josephine laid only 5 hatchlings emerged – the lowest fertility rate since the first fertile eggs six years ago. These five hatchlings bring the total up to 150 juveniles.

On the positive side, we have 150 tortoises ranging in age from 6 months to 5 ½ years with the largest of these juveniles now weighing close to 20 kilos. We can now begin to plan the first release for some time in 2009. The experience gained from the release of the five adult *Dipsochelys arnoldi* tortoises in 2006 will help us plan the process for release of the fast growing juveniles over the next few years.

Seychelles Terrapin Conservation Project

For the first time since 1999 no eggs were laid by the terrapins, which may be a reflection of the problems with tortoise fertility. In January a recently hatched *Pelusios castanoides* was rescued from the road at the spa end of the hotel. It was brought to the captive breeding programme because of fear of its being crushed by the electric golf carts that use the road.

As part of NPTS collaboration with North island and Island Conservation Society, 15 adult *P. subniger* were brought to Silhouette to be quarantined prior to reintroduction to North island. They remained in one of our ponds for three months waiting to have blood and faecal samples taken as part of a health check prior to relocation to North island. Fortunately we received ample terrapin food and five new pumps from ExoTerra, our sponsors of the terrapin project, and were able to cope with these extra terrapins.

Silhouette Conservation Project

This year we were able to consolidate our relationship with Labriz Silhouette through the enthusiasm and support of the resident manager and his staff. They have generously helped us with a gift of expensive galvanised mesh with which we built a new juvenile tortoise enclosure. Together we planned the protective measures described above to prevent turtle hatchlings being disorientated by the hotel lights.

Most fortuitous of all though is the loan of their gardening staff once a fortnight to assist with the forest rehabilitation project. This area of forest adjacent to the sheath-tailed bat roost is an important foraging area for the bats and the restoration of native vegetation is very important. With their regular help we have been able to recover some lost ground following the loss of our previous assistant and have been able to extend the cleared area further down to the Anse Lascars road and into the foot of Mont Poules Marrons.

Further surveys and monitoring of selected species have been carried out across Silhouette as we continue to investigate the ecology of the island. We assisted

Dr. Bruno Santerre with his project to define the forest structure at various altitudes and look forward to incorporating his findings into our work.

In November 2007 President Jams Michel announced his intention to have part of Silhouette declared a National Park. We are very enthusiastic about this commitment as achieving protected status for the island is the main reason for the Silhouette Conservation Project. To date some meetings have been held but progress is slow. Set against this good news is the disturbing proposal to build a road across the island to facilitate the building of a new hotel at Grande Barbe. We have been involved in the EIA process and have stressed how disastrous would be the impact of a road on a previously biodiversity-rich environment.

Seychelles Sheath-Tailed Bat Project

With funding from Conservation International Madagascar we were able to replace some of our monitoring equipment and to extend searches for other possible roosts. With the help of volunteers all known roosts were visited and some sites which are similar to the existing site at La Passe but no occupied roosts have been found.

Most of our time this year has been spent analysing the recordings produced by the CCTV camera. We have managed to collect almost 12 months of data on both day and night-time recordings. An equally important effort has been put into restoring the habitat near the existing roost and in the known foraging area. This restoration work involves the removal of dominant alien species such as cinnamon. It is a slow and very labour intensive process because not all aliens can be removed at the same time; thinning of cinnamon allows other seedlings to develop in the shade of the remaining trees. Once the native/endemic understory develops the final clearing of the aliens can be undertaken.

Obituary

Two dedicated scientists who worked tirelessly on collections from Silhouette and other Seychelles islands passed away during the year. Dr. Daniel Lachaise from the Paris Centre for Scientific Research was a specialist *Drosophila* researcher and his warm enthusiastic support will be sorely missed. Dr. Michael Saaristo of Turku University in Finland and the specialist on Seychelles spiders passed away in April. He had not enjoyed good health over the last few years but had continued to work on his spiders until the last moment. He is a great loss to spider taxonomy and to his friends in Seychelles.

R. Gerlach
Chairman

2007 Publications

[Ami = Amirantes; Ald = Aldabra; Sey = Seychelles]

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First data on productivity and reproductive parameters of tropical roseate terns breeding on St Joseph Atoll, Seychelles

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Abstract: Nest-site characteristics and reproductive parameters of tropical roseate terns *Sterna dougallii* breeding on St Joseph Atoll (Amirantes, Seychelles) were studied in June-August 2006. The total breeding population of *ca*300 pairs included 3 different colonies located on two islands (Pelican and Ressource islands). Roseate terns nested at sea-level on coral rubble on average 0.4 m from neighbors and selected nest sites that offered more concealment within the available habitat. First eggs were laid between 16-23 June (50 pairs, small colonies), with the peak of laying occurring during the first week of July (250 pairs, large colony). Mean clutch size was lower in early birds (1.1 eggs/clutch) compared to peak-laying birds (1.5 eggs/clutch). The former experienced a complete breeding failure at the egg stage presumably due to predation, but in the main colony 70 chicks were found to have fledged within the usual period of 25-30 days reported for the species. Overall, productivity was estimated at 0.23 chicks per pair. Although the recently-discovered colonies on St Joseph Atoll may be at risk due to the high number of potential predators (land crabs/herons/turnstones), these data are indicative of a productive population in the absence of food shortage periods recorded during the season. Our results are compared to the long-established population on Aride island (Central Seychelles), where productivity has been monitored annually since 1984. This paper highlights the importance of St Joseph Atoll for the conservation of roseate tern colonies in the western Indian Ocean, which could be partly achieved by including it as Important Bird Area (IBA) in the Seychelles.

Key-words: *Sterna dougallii*, St Joseph Atoll, Indian Ocean, Aride, Inter-colony comparison

Introduction

The roseate tern (*Sterna dougallii* Montagu, 1813) is a widely and sparsely distributed seabird with its world's stronghold lying in the Indian Ocean (Gochfeld 1983). The species was still considered globally near-threatened (*sensu* IUCN Red List) until fairly recently owing to a dramatic extinction of known colonies over the past

decades (Collar & Andrew 1988). Following a more recent update, population levels appeared to have stabilised and it was removed from the Red List in 2004 (BirdLife International 2004). The population of the Seychelles is one of the largest currently known in the western Indian Ocean (Tree 2005), making the identification of potential limiting factors of both regional and global importance for the conservation of the species. Aride island hosts the largest colonies in the Seychelles with its annual breeding population estimated between a low of 607 pairs in 2004 and a high of 1,276 pairs in 2002 (Ramos *et al.* 2002, Monticelli & Ramos 2004). Recent census elsewhere in the archipelago have also reported smaller colonies irregularly present at the uninhabited islands of Go ettes (Farquhar Atoll; 15-20 pairs), African Banks, Etoile, and possibly Bancs du Providence (Rocamora & Skerrett 2001). On St Joseph Atoll, where roseate terns have been opportunistically reported in the past (e.g. Betts 1998), breeding activity was first confirmed in 2005 (Skerrett & Skerrett 2005). The size of this population was estimated at *ca*350 pairs, which suggests that St Joseph Atoll may host the second largest number of roseate terns breeding in the Seychelles.

Compared to their temperate counterparts, tropical roseate tern colonies show lower productivities, with frequent periods of food shortage causing complete breeding failures (Milton *et al.* 1996, Ramos *et al.* 2002). On Aride, long-term research on roseate tern breeding parameters (Ramos 2002; Ramos *et al.* 2002) suggests a strong selection for laying as early as possible (Ramos *et al.* 2002). In poor years, egg and/or clutch sizes is significantly smaller than in years of good food supply conditions, and productivity is low because only the earliest breeders have a reasonable chance to rear a single chick (Ramos 2001). Moreover, Aride-roseate terns seem to trade off clutch size/egg size for earliness of laying (Ramos 2001), which appears to be a strategy to overcome the often declining food supply conditions as the season progresses (Ramos & Monticelli 2007). To date, however, these patterns in productivity and reproductive parameters have not been compared with other tropical colonies in the western Indian Ocean, because other breeding sites were poorly studied. Published information suggests also that the impact of predation on productivity is relatively small in tropical populations (Milton *et al.* 1996, Ramos 2002), but data is only available for a limited number of sites.

In this paper, we studied nest-site selection and reproductive performance of roseate terns colonies on St Joseph Atoll, Seychelles during the 2006 breeding season. Data on the number of breeding pairs, breeding chronology, clutch/egg sizes, hatching success, and productivity (no. of fledged chicks per pair) was collected, and compared to the Aride colonies, where breeding success and other characteristics are annually monitored since 1984 (Ramos *et al.* 2002). Nest- site characteristics were also collected on St Joseph Atoll to evaluate the possible response of the species to predation pressure.

Methods

Study Area

Fieldwork was conducted on St Joseph Atoll (5 25'S, 53 20'E) in June-August 2006. The atoll (1.21km²) is part of the Amirantes group of Seychelles and consists of 14 flat, sandy coral islands (Fig. 1). The three largest (St Joseph, Ressource, Fouquet) are

covered with coconut plantations. A thorough search of the atoll by boat to locate colony sites was conducted several days after the first birds were seen flying in early June. Roseate terns breeding in open areas are susceptible to human disturbance (Gochfeld *et al.* 1998), hence precluding regular visits to the nesting area during the season. We thus opted to minimize the number of visits paid to the colonies, and monitored breeding parameters such as fledging success at reasonable distance from a boat with binoculars (counting fledglings).

Location of colonies and nest-site selection

Colonies were found at sea-level on coral rubble cays. One small colony was found on Pelican island (PI) and two were found on Ressource island (one small, RI1, and one large colony, RI2). Nest-site characteristics were recorded by using a method previously applied on Aride island (Ramos 1998). Five variables were measured at both nest-sites and random-points during two brief visits of 10-15 minutes each at the peak of laying to colonies on RI (21-22 June; Table1).

Population size and breeding parameters

The size of the small colonies was determined by direct counts of the number of nests during several brief visits (21, 22, 23 June & 8 July). The size of the large RI2 colony was estimated by counting the number of black heads of birds on a panorama picture of the colony taken in the late afternoon at close range from a boat (24 July; colony size = total no. of birds divided by two). Clutch size and egg volume were recorded accurately in the two small colonies, but in the large colony, a study quadrat at the edge of the colony was only visited once (5-10min) 16 days after the first egg was seen to obtain data on clutch size. We inferred egg external volume (V , cm^3) from egg length (L , cm) and breadth (B , cm), measured with calipers to the nearest 0.1mm by using $V=0.512*L*B^2$ (Stonehouse 1966). An egg shape index was also calculated as $100*B/L$ (Coulson 1963).

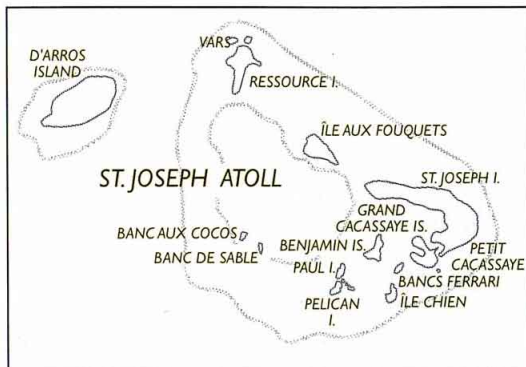


Fig. 1. Map of St Joseph Atoll (5°25'S, 53°20'E) showing the 14 flat, sandy coral islands. In 2005, roseate tern nested exclusively on Ile Chien (Skerrett & Skerrett 2005), in 2006 colonies were found on both Pelican and Ressource Islands (this study).

Table 1. Variables measured at roseate tern nest-sites and random-points on St Joseph Atoll during the 2006 breeding season.

Variable	Description (unit)
Object distance	Distance from the centre of the nest (egg) to the base of the nearest vertical object (log, coconut leaf, coral rubble) (cm).
Object height	Height of the nearest vertical object (cm).
Cover above nest	Object (log, coconut leaf) overhanging within a 30 cm radius from the centre of the nest (visual estimation, %).
Number of neighbour(s)	Number of neighbours counted within 1m radius around the nest.
Neighbour distance (NND)	Distance to the nearest neighbour nest (cm).

Table 2. Nest-site characteristics (mean \pm SD) of roseate terns breeding on St Joseph Atoll, Seychelles, in 2006. nd = no data

Variable	Nests (N = 22)	Random-points (N = 7)	Mann-Whitney- <i>U</i> (<i>P</i>)
No. of neighbours	4.0 \pm 2.0	nd	nd
Neighbour distance (cm)	38.4 \pm 15.6	nd	nd
Object distance (cm)	15.4 \pm 10.6	22.0 \pm 12.6	47.0 (ns)
Object height (cm)	18.1 \pm 13.6	4.1 \pm 2.9	7.5 (<i>P</i> < 0.001)
Cover above nest (%)	11.1 \pm 15.5	0	31.5 (<i>P</i> < 0.05)

Table 3. Summary of roseate tern breeding parameters and productivity (no. chicks fledged per pair) recorded at several colonies found on St Joseph Atoll and on Aride island, in 2006. Mean values are presented \pm SD with sample size in parenthesis (nd = no data).

Variable	St Joseph Atoll		Aride island
	Small colonies (early birds) ¹	Large colony (peak of breeding) ²	
Number of breeding pairs ¹	50	250	527
First egg-laying	16 June	1 July	1 June
Clutch size	1.1 \pm 0.3 (58)	1.5 \pm 0.5 (40)	1.1 \pm 0.2 (470)
Egg volume (<i>a</i> -egg) (cm ³)	18.5 \pm 2.2 (30)	nd	17.6 \pm 1.3 (40)
Egg shape index (<i>a</i> -egg)	72.3 \pm 3.1 (30)	nd	70.9 \pm 3.0 (40)
First chick hatching	no hatching	22-23 July	23 June
Hatching success (<i>a</i> , <i>b</i> -eggs) (%)	0 (58)	nd	74 (43)
Productivity (<i>a</i> , <i>b</i> -chicks fledged/pair)	0 (50)	0.28 (250)	0.51 (527)

¹Small colonies found on Pelican and Ressource islands. ² Large colony found on Ressource island

Productivity

Productivity (chicks fledged per pair) was assessed in the small colonies by recording directly egg/chick fate in each nest during four visits (21, 22, 23 June & 8 July). For RI2, two visits were conducted within an interval of two weeks (24 July, 9 August) to record chick fate and their stages of development at several nests randomly selected at the edge of the colony. Around 25 to 30 days following the estimated date of peak-hatching, fledglings were very mobile and started to assemble in crèches at one edge of the colony along the coastline. The number of large chicks and fledged young present in the colony area was subsequently counted on 25-27 August with binoculars from the boat to minimize disturbance. Productivity was estimated as the number of large chicks/fledglings divided by the number of pairs. However, it should be acknowledged that this method is likely to underestimate productivity because fledglings may hide during the count.

Comparison with Aride

The main colonies found on Aride are monitored annually following a standardised protocol described in Ramos (2001) and Ramos *et al.* (2002). Birds are habituated to human presence and breeding parameters and colonial productivity are estimated from marked nests followed in two study quadrats along the season. In 2006, roseate terns breeding on Aride were studied in June-August (Monticelli & Ramos 2006, this study).

Statistical analysis

Nest-site variables were compared to random-points using non-parametric statistics (Mann-Whitney *U*-test). Egg volume and egg shape index were compared between Aride and St Joseph Atoll using *t*-tests (difference between means) after controlling for unequal variances between samples. We used Fisher Exact tests to compare clutch size and productivity with estimates available for Aride in 2006.

Results

Nest-site selection on St Joseph Atoll

The mean distance to the nearest roseate tern nest was about 0.4 m, and there was a mean of 4 neighbours (min = 1; max = 8) within a 1m radius from the centre of each nest (Table 2). Objects found around nests (logs, coral rubble) were taller than would have been expected by chance, and the percentage of cover (coconut leaf, logs, detritus) was higher than that found at random-points (Table 2). Altogether, this suggests that roseate terns selected nest sites that offered some concealment within the available habitat.

Population size and breeding chronology

A first wave of early birds appeared during the second half of June (Table 3), and 50 nests were counted on 2 islands *ca* 1 km distant (PI = 15, RI1 = 35 nests). From our regular visits to the area, we estimated that the first clutch was initiated after 15 June, and that most clutches were laid between 16-23 June. The bulk of the roseate tern population arrived on St Joseph Atoll during the first week of July and egg-laying commenced almost immediately in a large newly formed colony (RI2) where a minimum of 250 pairs were estimated (500 birds on photographic document taken on 8 July).

Breeding parameters and productivity

Clutches laid between 16-22 June were significantly smaller than those laid in the peak laying period (after 1 July) at the RI2 colony (Fisher exact test $P < 0.001$; Table 3). Freshly broken eggs were found at the first visit to PI (8 out of 15 nests on 21 June) and subsequently during monitoring in June-July at PI and RI. A complete breeding failure of early birds was recorded at the egg stage due to heavy predation (PI, RI sites), presumably by land crabs (*Ocypode* sp.), turnstones (*Arenaria interpres*) and/or grey herons (*Ardea cinerea*) that were commonly seen in the immediate vicinity of the colonies. Because all eggs from early clutches laid on St Joseph Atoll failed, the first chick hatched around 23 July in the main RI2 colony (Table 3).

Despite the complete breeding failure recorded during the first half of the breeding season there was, however, no major predation event or food shortage period recorded at RI2 in August, with growing chicks at various stages of development observed during several visits (24 July-9 August). Chicks were successfully raised at RI2 throughout the month with a peak count of 70 fledglings at this site on 25-27 August. Overall, the productivity estimation was 0.23 chicks/pair.

Comparison with Aride in 2006

The 2006 Aride-population was estimated at 527 pairs with the first egg seen in the main hill woodland colony on 1 June, and the first chick hatching on 23 June (Table 3). The mean clutch size recorded for the whole population was similar to that of early birds laying in the small colonies on St Joseph Atoll. However, larger clutches were laid on St Joseph Atoll at the peak of breeding in the RI2 colony compared to the Aride value (Fisher exact test $P < 0.001$). Egg volume and egg shape index were smaller for Aride than for the two small colonies of St Joseph Atoll ($t_{68} = 2.2$; $P < 0.03$, and $t_{68} = 1.9$; $P = 0.059$, respectively). Overall, productivity on Aride was estimated at 0.5 chicks/pair (Table 3).

Discussion

Predation and location of colonies

Predation was responsible for most egg failure recorded early in the season in the small colonies located on Pelican and Ressource islands (St Joseph Atoll). The loss patterns of eggs suggested primary predation by land crabs and avian predators such as turnstones and/or grey herons which are widely present in the atoll and may predate on eggs and chicks (Nisbet & Spendelow 1999, Barbour *et al.* 2000). Despite the lack of detailed information on egg/chick predation at the main colony on Ressource island, chicks were successfully raised at this site during the season, which overall enhanced productivity to 0.23 chicks per pair. Large colonies are continuously attended by many adults compared to small colonies, which may be more effective to drive off aerial intruders (Hernandez-Matias *et al.* 2003), and possibly land crabs (Burger & Gochfeld 1988). This could contribute to explain the differential predation observed between early and peak-nesting birds on St Joseph Atoll. In 2005, the main roseate tern colony was found on the nearby Ile Chien (Fig. 1) by Skerrett & Skerrett (2005), but this breeding site was completely abandoned in 2006. Since predated colonies are also more likely to be abandoned in subsequent years (Nisbet & Spendelow 1999), the colony shifts observed in 2006 may reflect a predator avoidance response. Altogether, these observations suggest that the location of the St Joseph Atoll colonies may be fairly unpredictable from year to year. In the Great Barrier Reef, there are also frequent failures and colonies appear to change location frequently (Milton *et al.* 1996). In contrast, the main roseate tern colony found under woodland on Aride is well-established, presumably due to the virtual absence of ground and avian predators, except from two lizards (*Trachylepis wrightii* & *T. sechellensis*), that are passive egg predators (Ramos 2001), and introduced common barn-owls (*Tyto alba*) that sporadically take adult birds (authors' unpublished data).

Nest-site characteristics

Roseate terns nested in the open on coral rubble, a similar nesting habitat to that reported from other tropical colonies (e.g. Virgin Islands; Norton 1988, and Puerto Rico; Shealer 1995). The average distance of 0.4m between adjacent nests found on St Joseph Atoll is similar to values reported for Aride (0.5m; Ramos 1998). The study of nest-site characteristics revealed that roseate tern nests were not closer to vertical objects than were the random-points. However, objects found in the direct vicinity of the nests were taller and had a larger cover than expected by chance (e.g. log, coconut sapling). These features seem to be similar to nest-site selection at other tropical colonies within a similar open habitat (e.g. Culebra, Puerto Rico) where nests are usually placed far from vertical objects where crabs usually hide (Burger & Gochfeld 1988). There is also a preference for sites where cover is available at reasonable distance (0.5m) for shade and chick protection against bad weather or avian predators (Burger & Gochfeld 1988), which is consistent with our findings.

Breeding characteristics

The comparison between Aride and St Joseph Atoll suggests some differences during the 2006 season. The initiation of breeding differed by at least two weeks, with the earliest birds found on Aride (1 June). Over the last 15 years (1985-2001) laying on Aride has started as early as mid May (13 May), and as late as mid June (14 June), but usually fewer chicks fledged when laying started in June due to lack of food (Ramos *et al.* 2002). Mean clutch size recorded on Aride fluctuates between 1.03 eggs/clutch in poor years and 1.55 eggs/clutch in years of good food supply conditions (Ramos *et al.* 2002). In the arctic tern (*S. paradisaea*), egg production (clutch size and egg volume) has been found to be limited by food availability around the colonies, with a tendency to delay egg-laying in poor years (Suddaby & Ratcliffe 1997). Therefore, the fact that most clutches were laid on Aride in June 2006 and contained a single egg indicates that roseate terns laid under relatively poor food supply conditions in that year. On St. Joseph Atoll, where egg-laying was delayed compared to Aride, early birds laid mostly one egg (June), but those from the main laying period (July) laid larger clutches (mean of 1.5 eggs/clutch), which is indicative of presumably better food conditions during egg formation. The higher mean egg volume found on St Joseph Atoll (early birds) suggests also better food conditions when compared to the Aride situation.

Roseate terns breeding on St Joseph laid slightly longer, more pointed eggs compared to Aride which is consistent with a higher proportion of younger breeders (Coulson 1963), that usually initiate nests later in the season (Burger *et al.* 1996). The delayed laying dates on Ressource island in July (i.e., one month later than on Aride) raises also the possibility of earlier failure in the season at a different unknown site.

Altogether, these data are indicative of a productive population on St Joseph Atoll with absence of food shortage periods recorded during the season. This situation seems rather contrasting with Aride, where an acute food shortage in July-August limited productivity at 0.5 chicks per pair (Monticelli & Ramos 2006, this study). Extensive shallows in St Joseph Atoll are not available to Aride birds and could represent a more reliable feeding area with longer periods of food availability during the breeding season

(June-August). More years of data collection at both sites will help to further elucidate whether the 2006 situation represents a general pattern.

Conservation implications

Successful breeding on St Joseph Atoll may be at risk due to a high pressure by both avian and ground predators, but further research is needed to fully evaluate this aspect. Disturbance is also a serious concern. The owners of the atoll are very keen to preserve the natural fauna and are aware of the need to minimise disturbance but the lagoon is sometimes visited by others, including tourists (especially for fly-fishing) and poachers (for whom the main target may be wedge-tailed shearwaters *Puffinus pacificus*). Population estimates in 2005-2006 were fairly similar (Skerret & Skerrett 2005, this study) and suggest that St Joseph Atoll holds the largest known roseate tern breeding colony in the western Indian Ocean after Aride, which confers it the criteria to be included as an IBA in the Seychelles (Category *A4i*; Fishpool & Evans 2001). As further support for this inclusion, St Joseph Atoll also meets IBA criteria under category *A4i* in respect of black-naped tern *S. sumatrana*, *A4ii* for wedge-tailed shearwater, and *A4iii* for its overall seabird population (more than 10,000 pairs; Fishpool & Evans 2001).

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Drosophilidae of Seychelles: biogeography, ecology and conservation status

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[†] A large part of this work was done by the late Daniel Lachaise. The energy and knowledge of our former colleague and teacher has been a major driving force behind much of the research into Drosophilidae of islands of the western Indian Ocean and, indeed, the rest of Africa and to him we owe an enormous debt.

Introduction

A comprehensive collection of Drosophilidae (Diptera) was made 100 years ago during the Percy Sladen Trust Expedition to Seychelles. Recent collections made on the same islands provide a significant opportunity to study the way the composition of a fauna changes over a long period of time. Of particular interest is evidence of extinction and of invasion. Remote oceanic islands like the Seychelles Archipelago also provide evolutionary biologists the opportunity to study how speciation occurs when populations are physically isolated by great distances from a mainland and by short distances island to island. The evolution of species of Drosophilidae on the archipelagos of Hawaii, Tristan da Cunha, Marquesas, and Samoa, has, in each case and like Seychelles, resulted in high levels of endemism and morphological diversity. But it is also true that on each archipelago native plant communities, upon which most insect communities depend, are succumbing to the dominance of invasive weeds and the impact of human activity. There is therefore much to be gained by carefully revising our knowledge of the taxonomy, the biogeography and insect-plant interaction so that conservation strategies are better informed.

In June 1908 the entomologist Hugh Scott went to Seychelles to join the Percy Sladen Trust Expedition in the final months of the second of the two voyages, he remained camping and collecting in the endemic mountain-forests of the larger islands until March 1909 after the expedition had ended (Thompson 1961). Scott collected on

Silhouette from August–November, on Mahé October–November, Praslin in November, Félicité in December, Mahé again in January and February and Anonyme in January. His specimens were eventually deposited in the Cambridge University Museum of Zoology and the British Museum of Natural History. Charles G. Lamb studied the material and documented its rich diversity; of the 25 drosophilid species collected by Scott, 20 were described as new. Lamb (1914) classified them into 13 groups that are now recognized as 12 genera (Lamb 1914).

Even as early as 1915 the importance of these discoveries of “unusual morphology” among species of *Drosophila* was linked to the study of genetics and the evolution of species. Cockerell (1915), in a review of Lamb’s work, wondered “whether [the *Drosophila* species] do in fact differ in ways at all paralleled by Morgan’s [*Drosophila*] mutants, or [are they] likely to have arisen in similar fashion. The important cytological paper by Metz, just published, represents one way of attacking this problem; the taxonomic results of Lamb, based on twenty species, afford us another” (Cockerell 1915).

Some 68 years later in 1977 Leonidas Tsacas and Jean David mounted a *Drosophila*-collecting expedition to the archipelago. They sampled from Mahé and Praslin and rediscovered most (22/25) of the species described earlier by Lamb. Additionally, they discovered an important species of the *D. ananassae* group, *Drosophila vallismaia* Tsacas, 1984. During the Oxford Seychelles Expedition a few years later in 1980, Nigel Varty and Susan North collected from Cousin and Praslin. Among their samples (in alcohol), Gerhard Bächli, recognized a new species of the *Drosophila melanogaster* subgroup which he subsequently described with Tsacas as *Drosophila sechellia* Tsacas & Bächli, 1981.

Taxonomically and genetically *Drosophila sechellia* is very close to *D. simulans* and *D. melanogaster*. While *simulans* and *melanogaster* have worldwide distributions, *sechellia* is restricted to Seychelles where it is intimately associated with toxic *Morinda* fruit. The implications of the discovery of *D. sechellia* are profound, not only for genetics, genomics and evolutionary biology in general, but also for affirming the conservation significance of the region (Lachaise *et al.* 1988, 2004). The importance of *Drosophila sechellia* cannot easily be exaggerated. In a recent major review of *Drosophila* genomics in *Nature* (Stark *et al.* 2007) *D. sechellia* is one of the key *Drosophila* species whose genome has been sequenced to completion.

Despite the rich diversity of species collected by Scott in 1908–1909 (Lamb 1914), by Tsacas and David in 1977 (Tsacas *et al.* 1981), and despite the addition of the high-profile species *Drosophila sechellia* and *D. vallismaia*, fieldwork targeting the Drosophilidae in Seychelles has, until the recent surveys, been limited. Specialist collecting effort during most of the last century was the summation of Scott’s collecting on five islands over seven months and Tsacas and David’s work on two islands for one month. Until the current Franco-Seychellois CNRS-ICS-NPTS field survey program (2003–2007) many islands had not been sampled for Drosophilidae. Incidental records (the bi-catch from other entomological work) and observations of that part of the fauna easily attracted to fruit offered some indication. Apart from the limited amount of collecting (not withstanding the recent surveys), there has also been a bias favouring

the inner granitic islands rather than the outer coralline islands. But in this respect the expectation of discovering a rich fauna of plant- or fruit-breeding drosophilid species was low. In commenting on the composition of the insect fauna of Aldabra, Cogan *et al.* (1971) wrote: “In any area close to the shore it was noted that the lesser fruit flies (Diptera-Drosophilidae) were actively displaced from the niche they commonly fill, i.e. fermenting fruit and vegetation, by small shore flies of the family Tethinidae. Rotting fruit in fly traps rarely produced drosophilids, but always very large numbers of four species of Tethinidae. It is obvious that the species of Tethinidae breeding in shore litter, rotting seaweeds, etc., are naturally attracted to fruity odours and the products of decomposition, and occur in such numbers that they are able to successfully compete with the fruit flies for the available food.”

Justin Gerlach’s (NPTS) Indian Ocean Biodiversity Assessment (2000–2005) marked the centenary of the Percy Sladen Trust Expedition to the Indian Ocean and presented an excellent opportunity to collaborate and maximise outcomes for biological science. A joint Franco-Seychellois team (CNRS-ICS-NPTS) carried out a field survey over several years from 2003–2007 with the objective to assess the current status of the biodiversity of the species of Drosophilidae in Seychelles.

The 41 species we have recorded has nearly doubled the previously known fauna. Some species remain undescribed, several are known only by unpublished notes or observations and in some cases specimens are unsuitable for description. The fauna is now classified into 12 described genera and one which is still *incertae sedis* in *Drosophila* (Cariou *et al.* 2008). A question we ask is: to what extent has the native drosophilid fauna been endangered by the spread and colonization of invasive species? The present work presents an account of the biogeography, ecology and conservation status of the Seychellois drosophilid fauna.

Materials and methods

The species that are common and abundant now but were absent or not collected 100 years ago (1908–1909) or 31 years ago (1977) are of particular interest. To have such comprehensive collecting records for Drosophilidae spanning such a large period of time is almost unique in the world. Over the last one hundred years contributions to knowledge of the drosophilid fauna has come from either faunistic surveys specifically targeting drosophilids or by way of other entomological survey work.

Origins

In discussing the biogeography of this fauna we use the terms endemic, introduced and invasive. We use *endemic* for species currently known only from islands of the Seychelles Archipelago and caution that the fauna of Madagascar is still poorly known. We use the term *introduced* for non-endemic species that have been reported from Seychelles but never in very large numbers (e.g., *Drosophila hydei*, *D. immigrans* and *Dettopsomyia formosa*). We use the term *invasive* to describe those non-endemic species which are present in huge numbers and at many localities, especially abundant in disturbed (non-native) habitats. The obvious examples of invasive species in the present surveys are *Drosophila malerkotliana* and *D. nasuta*. When scoring the

frequency of specimens of species in general collections one always needs to bear in mind that two important phenomena distort the outcome: on the one hand collectors are often targetting particular species collecting all of them (e.g. *D. sechellia*) and on the other hand collectors become reluctant to keep collecting super abundant species (e.g. *D. malerkotliana*) eventually collecting none of them. Our application of the three terms is therefore based on numbers of specimens collected *and* first-hand field experience.

Diversity

Twelve genera of Drosophilidae are represented in Seychelles (*Chymomyza*, *Dettopsomyia*, *Dichaetophora*, *Drosophila*, *Hirtodrosophila*, *Hypselothyrea*, *Leucophenga*, *Microdrosophila*, *Mycodrosophila*, *Scaptodrosophila*, *Scaptomyza* and *Zaprionus*) and 41 species (Table 1).

The composition of the drosophilid fauna of Seychelles is changing. In its present state the fauna includes eight subcosmopolitan species, seven in common with Africa and two in common with both the Afrotropical and Oriental regions. On the other hand, 17 species are probably endemic. The remaining species probably also exist in Madagascar, a country still poorly surveyed, or on the African continent (Cariou *et al.* 2008). The increase in the number of species (24 in 1909 to 41 in 2007) is due mainly to more focused collecting over a wider range of habitats and islands, but is also due to the arrival of introduced or invasive species. Two species, very abundant in 1977, 2003 and at present, were probably not present in 1908, and were thus introduced between these two dates: *D. malerkotliana* and *Zaprionus tuberculatus*. The former is probably the most successful and vigorous colonizer of Afrotropical regions (see David & Tsacas 1981; Lachaise & Silvain 2004).

The high conservation value of the Vallée-de-Mai, Praslin

22 species of drosophilids were recorded in the Vallée-de-Mai (Praslin) during intensive surveys in 2003 (Table 2). This represents 54% of the total drosophilid fauna recorded from all of the islands of the archipelago. Moreover, 29% of these drosophilids are endemic to Seychelles. Two of them (*Drosophila vallismaia* and *Drosophila* sp. c) are known only from the Vallée-de-Mai. Four of the taxa collected at this important locality are probably new species overlooked in early fieldwork.

Ecological data obtained during the 2003 field studies in the Vallée-de-Mai has provided further evidence that preservation of the endemic plant community is key to the survival of a wide range of arthropods. The present drosophilid surveys have highlighted the importance of, among other plants, the endemic *Pandanus* palms. An important discovery made during these surveys is evidence that *Drosophila vallismaia* Vallée-de-Mai is intimately associated with the coco-de-mer palm *Lodoicea maldivica*. The fruitfly species was repeatedly found only on the coco-de-mer fruits and nowhere else. It was shown to breed in the dense, fibrous, and mildly flavoured husk of the nut. This coco-de-mer fruit husk is prone to alcoholic fermentation which makes the decaying plant tissue suitable as a resource for *Drosophila*. Yeasts that are host-specific on *Lodoicea* are probably also involved. It is extremely rare among drosophilids worldwide for a species to have such a small home range. This makes it particularly

Table 1. Drosophilidae of Seychelles

1a. granitic islands

Endemic	Mahé	Cerf	Long	Anonyme	Silhouette	North	Praslin	Curieuse	Cousin	Cousine	Aride	La Digue	Cocos	Félicité	Frégate
<i>Leucophenga grossipalpis</i>	•		•		•		•							•	
<i>L. sericea</i>	•				•		•								
<i>Dichaetophora aberrans</i>	•				•										
<i>D. sechellia</i>	•				•		•		•	•	•	•	•		•
<i>D. vallismaia</i>							•		•						
<i>D. sp. c</i>							•								
<i>D. sp. d</i>					•										
<i>D. spinipes</i>	•				•		•								
<i>Hirtodrosophila sp. e</i>	•				•		•								
<i>Hypselothyrea notabilis</i>	•			•			•				•				
<i>M. nigrobrunnea</i>	•						•								•
<i>M. sp. f</i>	•														
<i>M. sp. g</i>	•														
<i>Scaptodrosophila finitima</i>	•	•			•										
<i>S. jucunda</i>	•				•		•								
<i>S. sp. h</i>							•								
<i>S. sp. i</i>	•				•		•								
<i>S. sp. j</i>					•										
<i>Scaptomyza punctiscutata</i>	•														
	14	1	1	1	11		12		2	1	2	1	1	1	2

Inidgenous	Mahé	Cerf	Long	Anonyme	Silhouette	North	Praslin	Curieuse	Cousin	Cousine	Aride	La Digue	Cocos	Félicité	Frégate
<i>Dettopsomyia sp. b</i>	•														
<i>Mycodrosophila fracticosta</i>	•				•		•		•		•	•			
<i>M. nigerrima</i>	•														
<i>Scaptodrosophila caliginosa</i>	•														•
<i>S. lambi</i>	•														
<i>S. rufuloventer</i>	•						•	•	•			•			
<i>S. triangulifer</i>	•				•				•						
	7				2		2	1	3		1	2			1

introduced	Mahé	Cerf	Long	Anonyme	Silhouette	North	Praslin	Curieuse	Cousin	Cousine	Aride	La Digue	Cocos	Félicité	Frégate
<i>Chymomyza bicolor</i>	•														
<i>Dettopsomyia formosa</i>	•			•	•				•		•				
<i>D. immigrans</i>	•					•						•			
<i>Drosophila ananassae</i>	•				•		•					•			
<i>D. melanogaster</i>	•				•						•				
<i>D. simulans</i>	•				•		•							•	
<i>Microdrosophila pleurolineata</i>	•				•	•	•								
<i>Scaptodrosophila latifasciaeformis</i>	•				•				•			•			
<i>Zaprionus indianus</i>	•				•							•			
<i>Z. tuberculatus</i>	•						•					•			
	10			1	7	2	4		2		2	5		1	

invasive	Mahé	Cerf	Long	Anonyme	Silhouette	North	Praslin	Curieuse	Cousin	Cousine	Aride	La Digue	Cocos	Félicité	Frégate
<i>Dettopsomyia nasuta</i>	•				•		•				•	•		•	
<i>Drosophila malerkotliana</i>	•				•		•	•	•			•	•		•
	2				2		2	1	1		1	2	1	1	1

1b Coral islands

Species	Denis	D'Arros	Aldabra
<i>Leucophenga</i> sp. a	endemic		•
<i>Drosophila malerkotliana</i>	invasive	•	
<i>Drosophila sechellia</i>	endemic	•	
<i>Scaptodrosophila latifasciaeformis</i>	introduced	•	
<i>Zaprionus indianus</i>	introduced	•	
		2	3
			1

interesting for population genetic and evolutionary studies but its hostplant association makes it equally interesting as an ecological model with considerable potential. *Drosophila vallismaia* is a member of the *D. ananassae* species group (Lemeunier *et al.* 1997; Da Lage *et al.* 2007), a group of species most speciose in Australasia and the Oriental Regions and of increasing interest in genomic comparative studies. This species is certainly one of the priority species deserving consideration in conservation programs in Seychelles.

Table 2. The Drosophilidae of the Vallée-de-Mai, Praslin (the endemic status of *Mycodrosophila fracticosta* is uncertain: a similar species [perhaps conspecific] is known also from La Réunion).

Species known only from the Vallée-de-Mai <i>Drosophila vallismaia</i> Tsacas, 1984 <i>Drosophila (Drosophila) sp. c</i>
Species endemic to Seychelles <i>Drosophila sechellia</i> Tsacas & Bächli, 1981 <i>Scaptodrosophila sp. i</i> <i>Hirtodrosophila sp. e</i> <i>Hypselothyrea notabilis</i> (Lamb, 1914) <i>Leucophenga sericea</i> (Lamb 1914) <i>Mycodrosophila fracticosta</i> (Lamb, 1914) <i>Scaptomyza punctiscutata</i> (Lamb, 1914) <i>Scaptodrosophila jucunda</i> (Lamb, 1914) <i>Scaptodrosophila latifasciaeformis</i> (dark brown scutellum) <i>Scaptodrosophila latifasciaeformis</i> (faintly striped pleura)
Species widespread in the Afrotropical Region <i>Drosophila hirtipes</i> Lamb, 1914 <i>Scaptodrosophila caliginosa</i> (Lamb, 1914) <i>Scaptodrosophila triangulifer</i> (Lamb, 1914)
Invasive and introduced species <i>Drosophila malerkotiana</i> Parshad & Paika, 1964 <i>Drosophila nasuta</i> Lamb, 1914 <i>Scaptodrosophila latifasciaeformis</i> (Duda, 1940) <i>Zaprionus indianus</i> Gupta, 1970 <i>Zaprionus tuberculatus</i> Malloch, 1932 <i>Drosophila ananassae</i> Doleschall, 1858 <i>Microdrosophila pleurolineata</i> Wheeler & Takada, 1964

Other associations between endemic host-plants and endemic drosophilids have been discovered during work in the Vallée-de-Mai. For example, the association of the rare and endemic *Hypselothyrea notabilis* (a wasp-like fly) on the fruits of the endemic “lantannien lat” (*Versaffeltia splendida*). Evidence is inconclusive but does suggest a host plant association. Another important plant in the Vallée-de-Mai is one of the four endemic screwpines, the “vakwa prasol” (*Pandanus hornei*). Only on recently fallen syncarps does one find the rare *Scaptomyza punctiscutata*, another endemic drosophilid with unusual morphology. It is also the resource upon which a new species, *Drosophila sp. c* has been found. Both *Versaffeltia splendida* and *Pandanus hornei* fruits have yielded a number of specimens of *Microdrosophila pleurolineata*. We consider this species to be invasive. It was apparently absent 100 years ago and we have records of it from a wide range of habitats (e.g. Jardin Marron on Silhouette) including ones close to buildings and in gardens, for example, the Botanical Gardens at Mahé).

The Vallée-de-Mai also provides suitable refuge for the famous *Drosophila sechellia* due to the presence of a few *Morinda citrifolia* (Rubiaceae) near the waterfall. This important *Drosophila* is highly adapted to this plant species which status remains controversial, native or recently introduced (Lachaise & Silvain 2004). This paradox is a real puzzle of the Seychellois fauna.

During the 2003 survey we focused much attention on the endemic *Ficus*

species that occur in the Vallée-de-Mai. There are wide radiations of *Drosophila* (*fima* species group) and *Lissocephala* (*juncta* and *sanu* species groups) involving dozens of species on the African mainland, and in Madagascar and the Mascarene islands. We failed to find any species of these drosophilid genera in the Vallée-de-Mai. Despite the presence of *Ficus reflexa*, *F. rubra* and *F. bojeri* on Silhouette, Aride and Mahé nothing was found there either. In the Vallée-de-Mai a few syconia (figs) of the African native, *Ficus lutea*, were present but the feeding efficiency of frugivorous birds and bats appeared to have left nothing suitable for strictly fig-breeding insects.

A major ecological finding concerning the Vallée-de-Mai is the growing importance of invasive species which represent a real threat to this World Heritage Site. Among these species, *D. malerkotliana*, a member of the *ananassae* species group like *Drosophila vallismaia* is the main threat. Like *D. vallismaia*, *D. malerkotliana* is a member of the *ananassae* species subgroup within the *melanogaster* species group. But unlike *D. vallismaia* it is what could be called a lightning invader. It is predominant in all habitats in Seychelles and its population sizes are so considerable that it represents already at least 90% of all drosophilids in the inner Seychelles. The species was not recorded by Hugh Scott in 1908-1909 despite intensive collection (Lamb 1914) indicating that its spread is posterior to the 1908-9. Its extant populations are innumerable, counting billion of individuals. The spread of the species has therefore undoubtedly occurred within the last century. The impressive spread of *D. malerkotliana* is not restricted to Seychelles, the same rapid extension being presently observed throughout the African mainland and South America, but nowhere to the same extent than throughout inner Seychelles.

In evolutionary ecology it is often argued that ‘a *Jack-of-all-trades is a master of none*’. This suggests that specialist species can generally coexist with generalists because they are more efficient than these latter in their own niche. However, *D. malerkotliana* is not such a generalist, it should rather be seen as a universal specialist. It can do whatever specialists do and can be more efficient than them even in their own niche. In the Vallée-de-Mai, *D. malerkotliana* takes advantage of the presence of *Artocarpus* (more especially the jackfruit tree *A. heterophyllus*) to enter the palm and vacoa forest and breed in any of the endemic host-plants which harbour sympatric endemic drosophilids. As the causal factor promoting the invasion of *D. malerkotliana* into the Vallée-de-mai is the presence of jackfruit, we strongly recommend that the threat be reduced by removing all *Artocarpus heterophyllus* from the Vallée-de-Mai.

Aride Island Nature Reserve

Only eight drosophilid species are known from Aride (Table 1). But Aride is an island of special interest for two reasons. Firstly, the population size of the two dominant species, *D. malerkotliana* and *D. nasuta* is unrivaled, reaching values much higher than elsewhere, even in mainland Africa. A single sample comprised between 50 and 100 thousand flies, in the proportion 75-80% *D. malerkotliana* to 20-25% *D. nasuta*. In this one sample (and others like it) there were more than two species present. The second major finding is that the endemic species *D. sechellia* could be extracted from these mass samples in quantities much larger than anywhere else: 1142 *D. sechellia*

individuals, by far the largest collection of *D. sechellia* ever made, was separated from the mass sample. It is worth noting that no more than 200 individual *sechellia* flies have ever been collected on Cousin island since the discovery of the species there in 1980. Clearly, the largest *D. sechellia* population is on Aride, followed by that of Denis island where *Morinda citrifolia* is abundant. Both islands supports very well established populations of *D. sechellia*, to what extent this reflects a recent phenomenon or is the result of a long term population dynamic, is open to speculation.

Aride differs from the other islands by the complete absence of representatives of the genus *Scaptodrosophila*. Many *Scaptodrosophila* species are associated with palms. In many parts of Africa a relationship exists between the diversity of *Scaptodrosophila* species and the diversity of endemic palm species. Unlike Mahé, Praslin and Silhouette, Aride island has probably never had endemic palms. In this way, information about the biogeography and ecology of drosophilids contributes to understanding the history of an island's flora. Another interesting observation is that the dominant *Scaptodrosophila* species differs from one island to another, the reason for this is unclear.

Silhouette island

The three closely related species *Drosophila melanogaster*, *D. simulans* and *D. sechellia* were all found on Silhouette in 2003 and 2007. *Drosophila melanogaster* is confined to La Passe and is most likely a recent introduction from Victoria harbour on Mahé where *D. melanogaster* was apparently confined until recently. *Drosophila melanogaster* is exceedingly rare in Seychelles. *D. simulans* was collected at all altitudes from sea level (La Passe), and c.50m in elevation (Anse Lascars) to nearly 400m below Gratte Fesse and Jardin Marron. *Drosophila sechellia* is reported for the first time from Silhouette at Anse Lascar, La Passe and near the church. Consistently with records from Cousin, Aride, Praslin, Frégate and Mahé, it is restricted to the fruits of *Morinda citrifolia*.

Discussion

Lamb's (1914) comprehensive documentation of the species of Seychelles one hundred years ago allows us to determine the extent to which the native drosophilid fauna is impacted by invasive species. It should be stressed, however, that we have found no evidence that any endemic drosophilid species has been driven to extinction since 1908. Indeed the number of species now known to occur in Seychelles (41, see Table 1) is much more than the 24 collected by Scott and described by Lamb. This is due partly to the arrival of invasive species but mostly to the discovery of rare or specialized species overlooked during earlier expeditions.

A major finding is the overwhelming dominance of the invasive species, *Drosophila malerkotliana* and *D. nasuta*. Together they represent some 90% of all drosophilid individuals collected in the inner Seychelles, a situation that did not exist in 1908-1909. The former species represents 70–80% of the current multi-species community on any one of the granitic islands. This was not the situation in the early twentieth century. As a result of the pervasiveness of the two dominant *Drosophila* species,

the endemic fauna is considerably diluted on any particular fruit resource. On Aride, the endemic *D. sechellia* was 100 times less frequent than the invasive *D. malerkotliana* and only one specimen in one hundred thousand fruitflies was *Dettopsomyia formosa*. In 1908-9, the fauna was not so skewed. Note for instance that the now rare species *Leucophenga sericea* was then found throughout the damp endemic mountain-forests of Mahé (Lamb 1914: 328). Even if our sampling sites do not exactly match those reported by Lamb, it is likely that a change in the ratio of species abundance has resulted from a habitat change within the last hundred years.

Most of the land surface of the inner Seychelles is covered by introduced plants, notably the Prune-de-france *Chrysobalanus icaco* (Chrysobalanaceae), a tropical American bush introduced in the early twentieth century and that has now colonized the deforested slopes of Mahé, Praslin and Curieuse (Matyot 1998). Apart from cinnamon *Cinnamomum verum*, other such widespread invasive plants include Moraceae (e.g. *Artocarpus heterophyllus* and *A. altilis*), Mimosaceae (e.g. *Albizia lebbek* and *Adenanthera pavonina*), Melastomataceae (e.g., *Clibidia hirta*), or Bignoniaceae (e.g. *Tabebuia pallida*). These alien plants have provided a resource to which the invasive *Drosophila* species are well-adapted and the endemic or native species are maladapted. Concomitantly, the decrease of endemic trees like *Northea hornei* (Sapotaceae) has probably resulted in the contraction of the range of endemic *Drosophila*. It is, therefore, quite surprising that no drosophilid species has disappeared altogether since 1908. All species reported in 1914 have been rediscovered at least on one island, and new species have been discovered mostly during our 2003 field trips. It is worth stressing that most endemic drosophilid species that are recorded as new were discovered during our 2003 field work in remote patches of endemic palms and *Pandanus* spp., for example the Vallée-de-Mai and La Réserve on Praslin and Mahé respectively. The Vallée-de-Mai alone harbours 52% of the fauna of Drosophilidae of the inner Seychelles islands. It is most clear that these protected areas (gazetted or potential Nature Reserves) act as ultimate refuges for the endemic fauna of invertebrates. Outside these reserves invasive species dominate the altered or damaged environments. The “bigay” of mangos, guava and jackfruits are undesirable, whereas those of coco-de-mer, latanier palms and *Pandanus* are part of the biological legacy of Seychelles.

Two species of *Drosophila* have especially important scientific value - *Drosophila vallismaia* and *Drosophila sechellia*. Both were discovered and described in the 1980s. The reason for their “late appearance” in the history of the study of this fauna is their specialized ecological preference. Had Scott focused his sampling on *Morinda* or on coco-de-mer palm he most probably would have made the discoveries. A major finding of our 2003 survey was that *Drosophila vallismaia* is tightly restricted to the *Lodoicea maldivica* fruit husks, accounting for the confinement of this species to the Vallée-de-Mai (the species has not been found in the Fond Ferdinand *Loidicea maldivica* forest on Praslin, nor on a translocated coco-de-mer palm in the Jardin Marron on Silhouette). The *Lodoicea maldivica*/*Drosophila vallismaia* association exemplifies the endemic plant/endemic insect association.

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Population and conservation status of the reptiles of the Seychelles islands

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Abstract: The population sizes of most Seychelles reptiles was assessed through transects and focal counts for squamates and literature reviews for chelonians. Population density estimation tested several different sampling methods: transects, focal counts, leaf-litter quadrats and drift fences. Transects were suitable for estimating populations of skinks and snakes. Focal counts were more effective for geckos. Population assessments are made for all species except the cryptic *Urocytyledon inexpectata*. The data presented here allow the first attempt to assign IUCN Red List categories to all Seychelles reptiles; nine taxa are considered to be Vulnerable (*Ailuroonyx tachyscopaeus*, *Ailuroonyx trachygaster*, *Dipsochelys dussumieri*, *Janetaescincus veseysfitzgeraldi*, *Phelsuma a. abbotti*, *P. abbotti sumptio*, *Phelsuma sundbergi ladiguensis*, *Trachylepis wrightii* and *Zonosaurus madagascariensis insularis*), four Endangered (*Chelonia mydas*, *J. braueri*, *Lamprophis geometricus* and *Lycognathophis seychellensis*) and three Critically Endangered (*Eretmochelys imbricata*, *Pelusios subniger parietalis* and *P. castanoides intergularis*). The major threats to these species are intrinsically small ranges, habitat deterioration and, for some species, predation by introduced tenrecs.

Island faunas are widely recognised to be both of great conservation significance as biodiversity hotspots and as being highly threatened (Whittaker 1998). Major threats include development pressures and invasive species. These have had a significant impact on island reptile faunas with 26% of threatened reptiles being restricted to islands (overall 61% of all evaluated reptiles are categorised as threatened compared to 85% of evaluated island reptiles) (data from IUCN 2004).

The Seychelles islands support a notable diversity of reptile species divided into two major biogeographical groupings: the granitic and coralline islands. The granitic islands support 30 reptile species and subspecies (24 endemic) of 20 genera (6 endemic) and 14 amphibian species (13 endemic) of 7 genera (6 endemic, including two placed within an endemic family). The coralline islands support a less diverse and more cosmopolitan fauna of 10 reptiles (1 endemic) of 8 genera and no amphibians.

The herpetofauna of the Seychelles islands is well known taxonomically and basic ecological data exist for most species. The native species play an important role in the ecology of the islands, being common insect predators and flower pollinators (Cheke 1984; Gardner 1986). They are also the main prey items of the endemic vertebrates, such as the Vulnerable Seychelles kestrel (*Falco araea*) and the Endangered Seychelles bare-legged scops owl (*Otus insularis*) (Watson 1981; Gerlach 2002a). Monitoring procedures and data on population sizes and distributions exist for all the species of chelonians but little is known of the population sizes of the other reptiles. During preparation of the Seychelles entries for the Global Reptile Assessment it has become apparent that the accuracy of assessment for several species is limited by the lack of reliable population

data. The need to provide such data and to develop a population monitoring programme initiated research into population sizes. The results of this research are discussed here.

Methods

Population assessments for Seychelles Chelonia are well developed (Bourn *et al.* 1999; Marine Conservation Society of Seychelles 2005; Gerlach 2008) and no new assessments were made for the present study. New assessments were made for all squamate species. Transect data from 46 islands were collected in 2000-2005 and these were combined with results from tests of other methods in April and July 2005 on the large, diverse islands of Mahé, Silhouette and Praslin. Data were collected from 36 of the granitic islands (no data were collected from Moyenne, Long, Round island [Mahé], Round island [Praslin] and Chauve Souris [Praslin]), four coral cays, two raised coral islands and four coral atolls. Four census techniques were used:

1. Quadrats – in each habitat area 10 randomly placed 1m² quadrats were studied, for each of these a 20cm wide band of leaf litter was removed from around the quadrat and then leaf litter removed progressively from the quadrat. The 20cm band enabled any escaping reptiles to be detected. Within the quadrat all moveable rocks and logs were overturned. This was carried out on all islands. Quadrats provide direct density estimates for each habitat type. Habitats were identified a priori using the classification of Gerlach (1998).
2. Transects – over 10 years (1995-2005) 9 regular transects were walked on Mahé, 12 on Silhouette, 3 on Praslin, one on Curieuse and one on La Digue. These transects were walked in March-April, June-July, September-October and December-January. 9 occasional transects (walked on 1-2 occasions) were used on Mahé, 4 on Silhouette and 3 on Praslin. A further 32 transects were used on single occasions on the other islands in 2000-2005. Transects were 2m wide and of varying length. Geckos usually remained immobile when encountered and were easily recorded by a single observer. Skinks rapidly hid from observers and were only recorded in a 1m width of the path as individuals to the side of the path could not all be identified to species. Along each transect the number of reptiles observed in 100m stretches was recorded. Along one transect (Jardin Marron, Silhouette) the position of each reptile observed was recorded in metres along the path and centimetres from the mid-line in July 2005. The data obtained were used in population estimation.
3. Drift-fences – a study of the efficacy of drift fences was carried out on Silhouette island in April 2005. 5 drift fences 10m long were constructed at different altitudes (0, 50, 100, 380 and 390m). The drift fence was 50cm high and at every 2m a 25cm diameter, 30cm deep pot was sunk into the soil. Each pot was emptied twice per day, any captured reptiles were marked on the back of the neck with paint.
4. Focal counts - 100 trees were randomly selected in each main habitat and examined carefully for the presence of geckos using binoculars. At each focal point 10 quadrats of 5x5m was used to record the number of each tree species present in the area, this allows reptile numbers per tree of each species to be converted to a population density estimate.

Table 1. Transects used in the Seychelles islands. Transect numbers show in Fig. 1

Island	Transect	Length (m)	day	No. surveys		Altitude (m)	Habitat	
				night	total			
North	1	900	1	-	1	0-10	coconuts	
Silhouette	2	900	2	-	2	10-150	lowland - degraded	
	3	1400	7	-	7	0-550	lowland - high forest	
	4	500	16	-	16	200-250	mid forest	
	5	100	40	-	40	550-600	high forest	
	6	3400	16	-	16	0-250	lowland	
	7	1300	159	-	159	550-650	high forest	
	8	800	17	-	17	0-500	lowland - high forest	
	9	1800	24	-	24	100-500	mid - high forest	
	10a	400	4	-	4	10-200	lowland	
	10b	50	12	8	20	200	lowland	
	11	500	4	6	10	10-20	lowland	
	12	700	2	-	2	0-300	mid forest	
	13	600	2	-	2	400-600	high forest	
	14	500	1	-	1	0-150	lowland	
	15	2000	10	-	10	0-350	bracken	
	16	400	4	-	4	650-770	moss forest	
Mahé	17	1750	4	-	4	500-550	high forest	
	18	4000	2	-	2	500-600	high forest	
	19	2000	1	-	1	0-30	lowland	
	20	3000	10	-	10	250-500	high forest	
	21	200	2	-	2	0-50	lowland	
	22	200	4	-	4	300-320	degraded	
	23	500	3	-	3	300-350	degraded	
	24	200	3	-	3	350-400	high forest	
	25	1500	1	-	1	350-600	high - moss forest	
	26	600	2	-	2	250-350	degraded	
	27	800	5	-	5	300-350	high forest	
	28	1300	16	-	16	250-450	palm forest	
	29	3000	1	-	1	50-250	mid forest	
	30	3000	1	-	1	0-400	mid forest	
	31	900	1	-	1	350-400	high forest	
	32	600	8	-	8	350-400	mid forest	
Therese	33	500	1	-	1	0-20	coastal	
Conception	34	500	1	-	1	0-50	coastal	
St. Anne	35	300	1	-	1	0-50	coastal	
Seche	36	50	1	-	1	0	Sea-bird	
Cerf	37	800	4	-	4	0-20	coastal	
Anonyme	38	400	1	-	1	0-20	coastal	
Praslin	39	4900	16	4	16	10-250	palm forest - mixed	
	40	2000	12	-	12	0-10	coastal	
	41	3000	1	-	1	50-150	degraded	
	42	2000	10	4	10	0-10	coastal	
St Pierre	43	50	2	-	2	0	Sea-bird	
Curieuse	44	2000	8	-	8	0-100		
Aride	45	400	12	-	12	0-100	Sea-bird	
Cousine	46	200	2	-	2	0-100	Sea-bird	
La Digue	47	3000	2	-	2	0-350	degraded	
Marianne	48	300	1	-	1	0-20	Coconuts	
Felicite	49	300	1	-	1	0-200	Coastal	
G. Soeur	50	400	1	-	1	0-10	Coconuts	

Table 1.	(cont).						
P. Soeur	51	200	1	-	1	0-10	Coconuts
Recifs	52	100	1	-	1	10-20	Sea-bird
Ilot Freg.	53	50	1	-	1	10	Sea-bird
Fregate	54	3000	2	-	2	10-200	Coastal
Booby	55	50	1	-	1	10	Sea-bird
Bird		400	4	-	4	0	Sea-bird
Dennis		400	4	-	4	0	Coastal
Assumption		400	1	-	1	0	mixed scrub
Aldabra	Picard	750	1	-	1	0	mixed scrub
	Polymnie	500	1	-	1	0	mixed scrub
	Esprit	50	1	-	1	0	mixed scrub
	Malabar	625	2	-	2	0	mixed scrub
	G. Terre	500	1	-	1	0	woodland
Astove	wood	3450	1	-	1	0	woodland
	scrub	500	1	-	1	0	mixed scrub
Cosmoledo	Menai	200	1	-	1	0	mixed scrub
	North	100	1	-	1	0	Sea-bird
	Grand Ile	1500	1	-	1	0	Coastal
	North-East	300	1	-	1	0	Sea-bird
D'Arros		500	2	-	2	0	Coastal
St. Joseph		400	1	-	1	0	Coconuts
Alphonse		400	2	-	2	0	Coconuts
St. Pierre		140	1	-	1	0	Casuarina

Following recent taxonomic revisions (Gerlach & Canning 1996; Gerlach 2002b, 2005a) all species of Seychelles reptile are easily identifiable. A possible exception to this is the burrowing skink genus *Janetaescincus*. This is widespread on Mahé, Silhouette, Fregate, Felicite, La Digue and Curieuse. Two species have been described in this genus: *J. braueri* sensu stricto is apparently restricted to high forest on Mahé and Silhouette whilst *J. veseftitzgeraldi* is found below 500m on several islands (pers. obs.). The validity of the latter species has been questioned (Cheke 1984) and their taxonomy is currently being revised; they are not distinguishable without capture and at present the distribution of the two species has not been clearly elucidated. In data collection no attempt was made to distinguish the two species, but following capture of 20 individuals all *Janetaescincus* collected below 250m were found to be *J. veseftitzgeraldi* and all over 500m *J. braueri*. Between these altitudes both species were encountered. The analysis considered lowland skinks (under 250m) were to be mainly *J. veseftitzgeraldi*, whilst high forest (over 500m) skinks were assigned to *J. braueri*.

For the tiger chameleon *Calumma tigris* environmental variables were recorded in each section of each transect: altitude (metres above sea level), aspect (flat ground, slope or valley), canopy cover (estimated percentage cover in 25% bands), estimated canopy height (metres) and vegetation composition. The latter variable was recorded using a 5x5m quadrat, in which all trees over 2m tall were identified and recorded. All chameleons observed within 2m either side of the transect line during daylight (all surveys 08:30-14:00 hrs) were sexed, measured and their location on the transect was noted. This method only provided information on chameleons visible from the

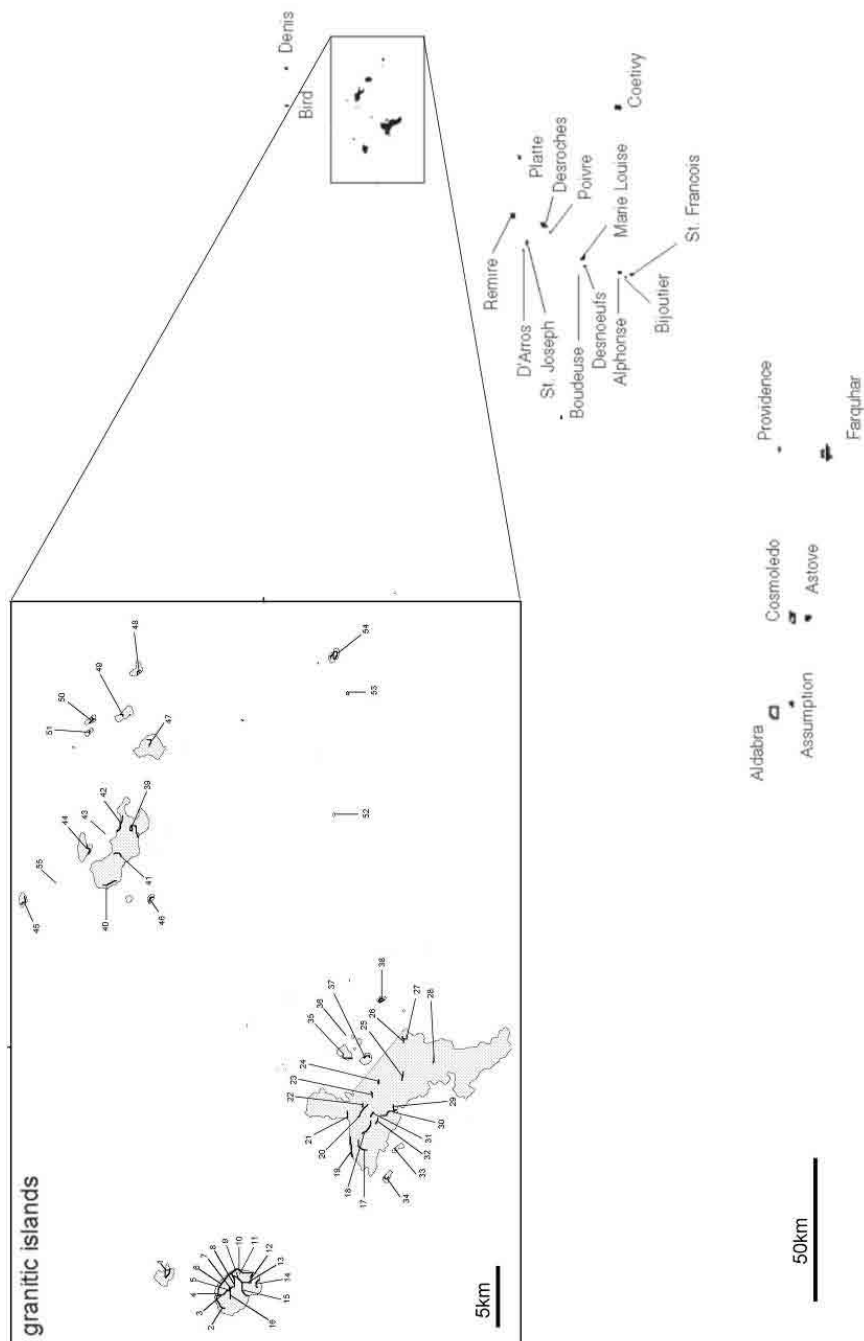


Fig. 1. Transects used on the Seychelles islands (transects numbered as Table 1)

path, excluding those on the far side of trees, more than 2m from the path and more than 2m above the ground. Chameleons (including other *Calumma* species) have been located in Madagascar by using nocturnal transects. It has been reported that as roosting chameleons become pale they are relatively easy to detect by torch light (Raxworthy 1988, 1991; Jenkins *et al.* 1999; Brady & Griffiths 1999). However, four nocturnal transects (Vallée de Mai, Praslin; 20:00-22:00 hrs) surveys have failed to locate *C. tigris*. The nocturnal lightening effect is minor in this species (pers. obs.) and this means that they are not easier to locate at night than by day. Although nocturnal searches are well established in chameleon research and are considered to be the most reliable survey method they did not prove effective with *C. tigris*; consequently only the diurnal transects are reported on here.

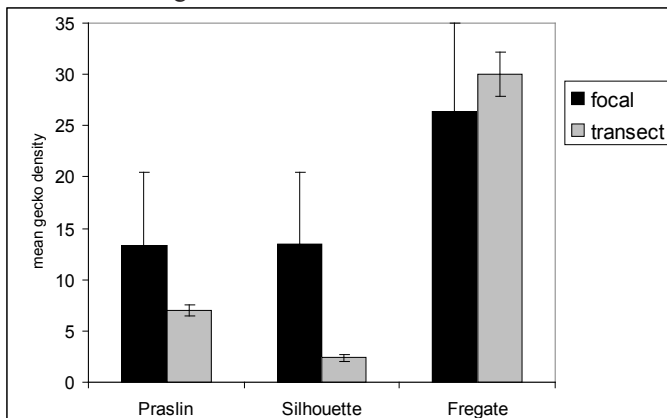
Results

Sampling methods

Only two reptile species were recorded in quadrats. The burrowing skink *Janetaescincus braueri* was collected in a single quadrat at Mon Plaisir, Silhouette (1000±3000ha⁻¹). On Fregate island *J. veseytitzgeraldi* and *Pamelaescincus gardineri* were recorded under rocks, with densities of 190.0±101.2 and 126.5±75.5ha⁻¹ respectively. They were not located in such sites on other islands and this appears to be a locally high density.

Snakes, skinks, chameleons and most gecko species were located using the transect method. The house snake *Lamprophis geometricus* was only recorded during the night transects, other reptiles recorded at this time were small numbers of the geckos *Ailuronyx seychellensis* and *A. trachygaster*. Distance based methods and classical line transects did not produce significantly different population estimates for the Jardin Marron transect. All estimates were within 95% of the estimates for classical linear transect methods.

Fig. 2. Comparison of transect data and focal counts for geckos on Praslin, Silhouette and Fregate islands.



Drift-fences recorded only one reptile species: the burrowing skink *Pamelaescincus gardineri*. Three individuals were captured in 25 trap days, the limited species range and low capture rate lead to this method not being pursued beyond an initial trial. Focal counts recorded only geckos but they produced higher counts of all geckos than the transects (Fig. 2).

Seasonality

Only one species showed significant seasonality: the snake *Lycognathophis seychellensis* was more likely to be encountered in November-December than in other months. The proportion of transects where snakes were encountered was not significantly different for these months but the numbers of snakes encountered were raised (from 1-2 to 8-12), this was largely due to local aggregations of snakes, probably associated with mating. No other significant seasonal effects were found for any other species.

Method evaluation

Of the methods used in this study, transects proved to be the most useful in terms of generating data and repeatability. Distance based methods did not affect the population density estimates. This method is preferable to classical transect studies when not all animals in the sample area are likely to be encountered (Buckland *et al.* 1993), in this case the narrow transects and the active nature of most of the reptiles concerned mean that the distance methods are not significant improvements. Although drift-fences were expected to provide effective collection of the skinks, only one species was trapped. Too few quadrats were used to provide sufficient data points for reliable analysis, and only recorded one reptile species. Focal counts were highly labour intensive but produced quantified counts of gecko abundance with greater precision than transects. However, they have high standard errors; sample sizes will need to be expanded considerably to produce reliable population estimation with this method.

The accuracy of the population estimates depend on the constancy of the detection rate (Schmidt 2004). In observation based studies this will be primarily affected by the visibility of the animals, which will in turn be a consequence of activity and environment. For the wolf snake *Lycognathophis seychellensis* the seasonal component of the transect data suggests an increase in activity associated with seasonal peaks of breeding. This does not appear to be the case for the other species, but vertical distribution has a strong effect on the detection of canopy dwelling species such as *Ailuronyx trachygaster* and *Phelsuma sundbergi* on Praslin. Surveys need to take these limitations into consideration.

Status assessments

Marine turtles Two breeding species of sea turtle are present in the Seychelles islands, the green turtle *Chelonia mydas* and the hawksbill turtle *Eretmochelys imbricata*. The former breeds mainly in the southern atolls, with some 3,400-4,750 females nesting annually, whilst the hawksbill is the main breeding species in the granitic islands, with 1,230-1,740 nesting (estimates from the 1980s - Mortimer *et al.* 1996). Numbers declined throughout the 19th and 20th centuries, but effective protection since 1994

appears to be stabilising populations (Mortimer 2000). Numbers of females nesting on the main nesting beaches are monitored annually, since 2006 this has been in the form of a national monitoring scheme (Marine Conservation Society of Seychelles 2005), no recent analyses of population trends have been published. The species are globally threatened, listed as Endangered for the green turtle and Critically Endangered for the hawksbill (IUCN 2004). Loggerheads *Caretta caretta* and leatherbacks *Dermochelys coriacea* have been recorded in Seychelles waters but do not breed (Frazier 1984).

Tortoises The most recent taxonomic revision recognises four species of *Dipsochelys* giant tortoise from the Seychelles islands (Gerlach & Canning 1998). The most familiar of these is the Aldabra giant tortoise *Dipsochelys dussumieri*. This has been the subject of conservation attention since the 1800s and has been extensively studied over the last 35 years. Populations declined to a low level (approximately 1000 individuals in 1900) (Gerlach 2004) as a result of direct exploitation. Protection of the atoll has enabled populations to recover to an estimated 100,000 in 1997 (Bourn *et al.* 1999). There is evidence of recent declines which are believed to be due to natural processes following over-population in the 1970s. The species is listed (as '*Geochelone gigantea*') as Vulnerable on the basis of restricted range (IUCN 2004). The only natural population is threatened in the long-term by sea level rise (although the well established introduced populations on Curieuse and Fregate islands are secure from this threat). Of the other species, *D. daudinii* is known from only two museum specimens collected prior to 1830 (Bour 1985), this species is presumed to be extinct. A small number of living tortoises have been ascribed to the species *D. hololissa* and *D. arnoldi* based largely on morphology (Gerlach & Canning 1998), genetic studies have failed to provide clear support for this identification; mitochondrial genes show no variation in the genus (Palkovacs *et al.* 2003), a combination of mitochondrial and nuclear genes have been used to suggest that a single species is present (Le *et al.* 2006) although the data do show some genetic differentiation, microsatellite primers from Galapagos tortoises show no population structuring (Palkovacs *et al.* 2003, although a different analysis was provided by Gerlach 2005) whilst Madagascar tortoise primers show significant separation but continued gene flow (Gerlach & Rioux-Paquette in prep.). The identity of these taxa remains a matter of debate. No wild breeding populations of *D. hololissa* remain (Gerlach & Canning 1998) and this can be categorised as Extinct in the Wild. *D. arnoldi* was reintroduced to Silhouette island in 2006. Both species are included in a successful captive breeding programme (Gerlach 2007).

Terrapins Three taxa of *Pelusios* mud turtle are endemic to Seychelles. Two are endemic subspecies of African species: *P. subniger parietalis* and *P. castanoides intergularis*. The third is an endemic species *P. seychellensis*. The first two are categorised as Critically Endangered on the basis of range restriction, fragmentation and continued declines in range, habitat and population (at least 70% in the last five years for *P. castanoides* and 31% for *P. subniger*; Gerlach & Canning 2001; Gerlach 2008). *P. seychellensis* is known from three specimens collected in 1895, despite extensive searches it has not been relocated and is probably extinct.

Crocodiles Historically crocodiles were present in the Seychelles islands, with *Crocodylus porosus* in the granitic islands until the early 1800s (Gerlach & Canning 1994).

Snakes Snakes have been recorded in all forest habitats, population densities are given in Table 2. The wolf snake *Lycognathophis seychellarum* is locally abundant in forests and transect data show no significant effects of altitude or habitat preference within the forest. It has high population densities on Silhouette and Fregate but comparatively low densities on Mahé and Praslin. This may be due to predation by tenrecs *Tenrec ecaudatus* but there is no direct evidence of this or of any population decline. The house snake *Lamprophis geometricus* was only encountered on the nocturnal transects in the Vallée de Mai, Praslin. An insufficient number of nocturnal transects have been used on Mahé or Silhouette for the abundance of this species to be determined on those islands. Both endemic snakes are considered to be Endangered due to their restricted ranges and the continuing decline in the extent and quality of its forest habitat, especially on Mahé and Praslin islands.

The introduced blind snake *Rhamphotyphlos braminus* was not encountered in any of the population surveys and no methods currently exist for monitoring its populations. It occurs widely, with records from both granitic and coral islands. The sea-snake *Pelamis platura* has been recorded in the islands (Gerlach 1999; Lawrence 2007) but there is no evidence of any breeding populations in Seychelles.

Skinks In the granitic islands skinks have clear altitude preferences as indicated by transect data, with *Trachylepis sechellensis* being a lowland species and the burrowing skinks being more abundant at high altitudes (Fig. 3), although all three occur at all

Fig. 3 Effect of altitude on skink density on Silhouette (individuals per hectare). *Pamelaescincus* $y = -4 \times 10^{-5}x^2 + 0.0216x + 4.6203$ ($R^2 = 0.48$); *Janetaescincus* $y = 0.0201e^{0.0149x}$ ($R^2 = 0.93$); *Trachylepis* $y = 43.61e^{-0.0075x}$ ($R^2 = 0.91$). $P < 0.05$.

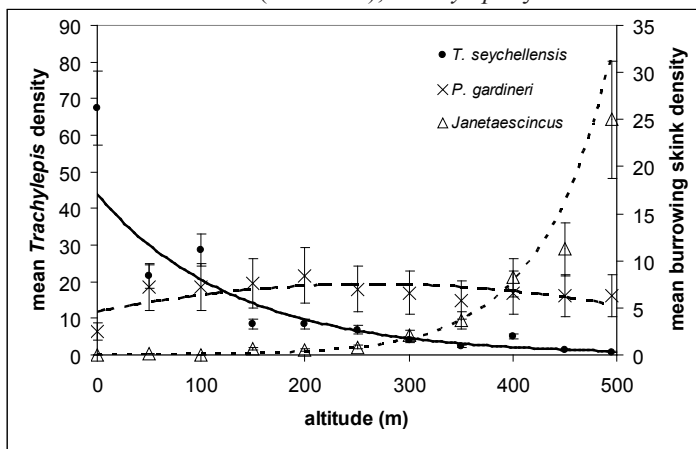


Table 2. Mean (\pm SE) density per hectare from transect data. 2a. snakes & lizards

Island	Habitat	I_{yc}	B_{od}	Ch	Z_m	\bar{x}_c	I_{w}	J_b	P_g
Mahe	lowland degraded	0	0	-	-	6.50 ± 0.25 1.20 ± 0.20	-	0	0
	mid forest	0	0	-	-	4.52 ± 0.69	-	0	1.73 ± 0.1
	Palm forest	0	0	-	-	0.92 ± 0.48	-	0	0
	High forest	0.34 ± 0.23	0	-	-	0	-	0	0.42 ± 0.07
	Moss forest	0	0	-	-	0.23 ± 0.19	-	0	0
Praslin	lowland palm forest	0	0	-	-	18.68 ± 5.1 15.1 ± 10.4	-	-	0
	mixed forest	0.08 ± 0.1	0	-	-	5.38 ± 2.33	-	-	0
	scrub	0	0	-	-	5	-	-	0
Curieuse	coastal	0	0	-	-	8.03 ± 2.53	-	0.52 ± 0.02	0.52 ± 0.02
La Digue	Degraded	10	0	-	-	33	-	-	30
Silhouette	Lowland	1.2 ± 0	0	-	-	57.73 ± 16.27	-	0.13 ± 0.01	8.92 ± 0.34
	mid forest	1.78 ± 3.38	0	-	-	2.32 ± 1.13	-	10.76 ± 0.36	26.69 ± 0.33
	high forest	1.01 ± 4.21	0	-	-	0	-	39.47 ± 1.02	36.95 ± 1.01
	moss forest	1.35 ± 1.15	0	-	-	1.3 ± 0.8	-	99.1 ± 0.83	288.76 ± 3.62
	Bracken	0.63 ± 2.1	0	-	-	9.23 ± 2.53	-	5.03 ± 0.25	14.4 ± 0.25
	Degraded	5 ± 2.5	0	-	-	24.18 ± 2.85	-	3.35 ± 0.39	35.89 ± 0.4
North	Coconuts	-	-	-	-	33,33	-	-	-
Cerf	coastal	-	-	-	-	42.19 ± 7.81	-	-	1.56 ± 1.56
St. Anne	Coastal	-	-	-	-	200	-	-	-
Anonyme	Coastal	-	-	-	-	100	-	-	-
Conception	Coastal	-	-	-	-	30	-	-	-
Therese	Coastal	-	-	-	-	50	-	-	-
Aride	Sea-bird	-	-	-	-	286.3 \pm 678.8 4000.1 ± 125.09	301.51 ± 52.6 3250.2 ± 101.1	-	100 ± 200
Cousine	Sea-bird	0	-	-	-	50	-	-	-
P. Soeur	Coconuts	-	-	-	-	100	-	-	-
G. Soeur	Coconuts	-	-	-	-	83,33	-	-	-
Felicite	Coastal	-	-	-	-	100	-	-	16.67
Marianne	Coconuts	-	-	-	-	100	-	-	-
Fregate	Coastal	0.83 ± 0.83	0	-	-	416.7 ± 101.1	366.7 ± 11 750 ± 5	0.83 ± 0.08	2.5 ± 0.08
St. Pierre	Sea-bird	-	-	-	-	-	-	-	-
Seche	Sea-bird	-	-	-	-	700	-	-	-
Booby	Sea-bird	-	-	-	-	800	-	-	-
Ilot Fregate	Sea-bird	-	-	-	-	300	-	-	-
Bird	Sea-bird	-	-	-	-	10 ± 2.11	-	-	-
Dennis	Coastal	-	-	-	-	-	-	-	-
Assumption	mix scrub	-	-	-	-	-	-	-	-
Picard	coast	100	-	-	-	-	-	-	-
Esprit	mix scrub	300	-	-	-	-	-	-	-
Malabar	mix scrub	20	-	-	-	-	-	-	-
	woodland	-	-	-	-	-	-	-	-
	woodland	-	-	-	-	-	-	-	-
G. Terre	woodland	-	-	-	-	-	-	-	-
Astove	mix scrub	-	-	-	-	-	-	-	-
	mix scrub	-	-	-	-	-	-	-	-
Menai	mix scrub	-	-	-	-	-	-	-	-
North	Sea-bird	-	-	-	-	-	-	-	-
Grande Ile	Coastal	-	-	-	-	-	-	-	-
North-East	Sea-bird	-	-	-	-	-	-	-	-
St. Pierre	Casuarina	-	-	-	-	-	-	-	-

2b. geckos

Island	Habitat	A_s	A_f	Atg	P_s	P_{gs}	P_{ab}	H_m
Mahe	lowland degraded	0	0	-	0.50±0.05	0	-	-
	mid forest	0	0	-	1.50±0	0.03±0.02	-	-
	Palm forest	0.36±0.01	0.44±0.02	-	0.15±0.01	0.22±0.05	-	-
	High forest	0	0	-	0.25±0.01	0.07±0.03	-	-
	Moss forest	0	0	-	0.35±0.02	0	-	-
Praslin	lowland	0	0	-	0.24±0.01	0	-	-
	Palm forest	10.42±3.01	27.88±1.62	0	8.03±0.24	6.8±2.55	-	-
	mixed forest	1.5±0.05	0.05±0	4.44±0.26	4.77±0.35	6.54±4.52	-	-
	scrub	0	0	0	2.21±0.01	3.25±0.5	-	-
Curieuse	coastal	0	0	-	0	0	-	-
La Digue	Degraded	0	0	-	1.25±0.06	1.25±0.63	-	-
Silhouette	Lowland	6	0	-	1.67	3.33	-	-
	mid forest	0.56±0.05	2.01±1.11	0	2.75±0.19	7.56±2.04	-	-
	high forest	0.31±0.18	0	0.05±0.01	0.43±0.01	1.67±0.15	-	-
	moss forest	2.99±0.27	0	0	0	0	-	-
	Bracken	3.5±0.02	0	0	1.4±0.08	0	-	-
	Degraded	0	0	0	0.83±0.02	0.23±0.18	-	-
North	Coconuts	0	0	0	3.72±0.1	3.32±1.99	-	-
Cerf	coastal	-	-	-	16.67	-	-	-
St Anne	Coastal	0	-	-	7.81±0.16	3.13±1	-	-
Anonyme	Coastal	0	-	-	50.00	66.67	-	-
Conception	Coastal	0	30	-	0	37.5	-	-
Therese	Coastal	0	-	-	0	40	-	-
Aride	Sea-bird	13.75±1.13	-	-	0	20	-	-
Cousine	Sea-bird	25±2.5	-	-	1±2	-	-	-
P Soeur	Coconuts	0	-	-	-	0.89±0.89	-	-
G Soeur	Coconuts	0	-	-	-	25	-	-
Felicite	Coastal	-	-	-	12.5	37	-	-
Marianne	Coconuts	-	-	-	33.33	50	-	-
Fregate	Coastal	10±0.17	-	-	33.33	66.67	-	-
St Pierre	Coastal	-	-	-	10±0.33	10±1.67	-	-
Seche	Sea-bird	-	-	-	-	200	-	-
Bird	Sea-bird	-	-	-	-	100	-	-
Dennis	Coastal	-	-	-	8±1.33	-	-	-
Assumption	mix scrub	-	-	-	11±2.13	-	-	-
Picard	coast	-	-	-	-	-	2.5	-
	mix scrub	-	-	-	-	-	10	20
Polymnie	mix scrub	-	-	-	-	-	10	-
Malabar	mix scrub	-	-	-	-	-	20	-
	woodland	-	-	-	-	-	5	5
G Terre	woodland	-	-	-	-	-	20	10
Asiove	woodland	-	-	-	-	-	145	-
D Arros	Coastal	-	-	-	-	2±0.83	-	-
Alphonse	Coconuts	-	-	-	-	6.25	-	-

altitudes. There is little seasonality in abundance. As with snakes, densities of the burrowing skinks are higher on Silhouette and Fregate than on Mahé or Praslin. Population densities on La Digue are comparable to those on Silhouette but only in a small area with the least degraded habitat. *T. sechellensis* is abundant at low altitudes on all islands, with highest density being recorded in *Pisonia grandis* woodland associated with sea-bird colonies. The sea-bird colonies are also the only places where *T. wrightii* is recorded. The population densities of *Trachylepis* skinks recorded here for sea-bird islands (Table 2, 5) are comparable to those reported by other studies with different methods (Evans & Evans 1980; Brooke & Houston 1983; Castle & Mileto 1991). Densities were comparatively low on small rocks and on Fregate island, the latter was heavily modified throughout the 20th century but now has an expanding tern population, skink densities may still be low due to historically small tern populations. On islands without tern-colonies *T. wrightii* is absent and *T. sechellensis* occurs at low densities.

Pamelaescincus gardineri occurs at relatively low densities on Mahé, Cerf, Praslin and Curieuse. Populations of *P. gardineri* have been suggested to be reduced by predation by rats (Cheke 1984) or tenrecs (Gardner 1986). Diurnal activity on Praslin, Mahé, La Digue and Fregate has been suggested to be due to nocturnal predator (barn owls and rats) avoidance (Cheke 1984), although such predators are not present on Fregate. Alternatively, high densities of *Trachylepis* skinks on the small sea-bird islands may force the smaller *P. gardineri* into a nocturnal niche (Evans & Evans 1980). The present study is the most extensive investigation of reptile populations on the granitic islands of Seychelles and provides a more reliable base for such comparisons. Two particular patterns are notable: for several reptile species population densities are comparatively low on Mahé and Praslin and the nocturnal behaviour of *P. gardineri* is restricted to the sea-bird islands where *Trachylepis* skinks are particularly abundant, and *T. wrightii* is present. This large diurnal skink has been seen eating smaller skinks and may be a major factor restricting *P. gardineri* activity. Reduced population densities on Mahé and Praslin (in comparison to Silhouette and La Digue) are apparent for all ground dwelling lizards except for *T. sechellensis*. However, arboreal geckos have comparatively high densities on Praslin. This comparison indicates that ground-dwelling reptiles on Mahé and Praslin have reduced population densities, which cannot be explained by the distribution of rats or cats (both present on Silhouette and La Digue where reptile densities are high) but does correlate to tenrec presence. These are restricted to Mahé and Praslin and are highly abundant on both islands. Tenrecs are known predators of large invertebrates and small vertebrates, including skinks and snakes (Racey & Nicoll 1984).

The least well known of the Seychelles skinks is the burrowing skink genus *Janetaescincus*. Cheke (1984) noted that its apparent confinement to “the Mahé group of islands and Fregate could well be due to the secretive habits of this species”. The present study extends the known distribution of *J. vesevitzgeraldi* to La Digue, Felicite and Fregate based on captured individuals identified to species. All *J. braueri* specimens have been collected from high altitude forests and the only islands with this habitat are Mahé and Silhouette.

Cryptoblepharus boutonii is only found in the southern atolls where it occurs at high population densities, in all habitats. It is considered Least Concern due to its wide

distribution, although all Seychelles populations are on low-lying islands vulnerable to sea level rise. *Pamelaescincus gardineri* and *Trachylepis sechellensis* are similarly not considered threatened, although *T. wrightii* qualifies for Vulnerable status due to its highly restricted range. *Janestaescincus braueri* is Endangered due to being restricted to two locations, with continuing decline in the extent and quality of its forest habitat on Mahé and Silhouette islands. *J. vesevfitzgerald* faces similar threats but has a wider range and is considered to be Vulnerable.

Other lizards With the exception of some of the geckos and *Cryptoblepharus boutonii*, the only non-endemic native lizard species in the islands is the Madagascar girdled lizard *Zonosaurus madagascariensis insulans*. There is also an introduced population of *Calotes versicolor* on St. Anne island. This may recently have been eradicated (R. Fanchette pers. comm.). The girdled lizard is restricted to Cosmoledo atoll where it has been located on Menai, North island and Grande Ile. The species is widespread in Madagascar but the Cosmoledo subspecies is found only on that atoll and Grande Glorieuse, it therefore qualifies as Vulnerable due to its very restricted range; this subspecies is likely to be threatened by sea-level rise in the long term.

Chameleon The tiger chameleon *Calumma tigris* has a relatively wide range in forest habitats on Mahé, Silhouette and Praslin islands. However, it is not evenly distributed in all habitats and is primarily associated with forested valleys.

Factors influencing chameleon distribution were evaluated by analysis of variance (ANOVA) using each 100m section of transect, comparing observed population densities with the habitat variables recorded in that section (altitude, numbers of each tree species, aspect, canopy cover and canopy height). Significant factors were then used to group similar transect sections. The final analysis used the following groupings: aspect (slope or valley) and habitat (lowland, mid-altitude, garden, palm rich, degraded, high forest, moss forest or scrub). The main influences were found to be aspect, habitat and proportion of native vegetation (Table 3). The proportion of native plants produced had only a weak effect on the ANOVA results, but significant correlation with the density of *Cinnamomum verum* plants was identified. This plant supports very few invertebrates and cinnamon dominated forest is typically very insect poor (pers. obs.), this may reduce the suitability of this habitat for insect predators such as chameleons. Use of aspect and habitat in grouping transects reduce the standard error of density estimates and these have been used in densities and population estimates (Table 4).

Table 3. ANOVA results for chameleon densities and habitat factors. *Cinnamomum verum*, the only significant single species, is treated separately

Factor	SS	Df	MS	F	P
month	407481.2	36	11318.92	1.007	0.472
aspect	1848948	1	1848948	82.360	<0.001
habitat	0.049	1	0.049	0.101	0.752
vegetation	0.351	1	0.351	0.620	0.436
<i>Cinnamomum</i>	92452	1	92452	42.603	<0.01
aspect + vegetation	0.708	2	0.354	0.787	0.459
habitat + aspect	2465664	2	1232832	82.267	<0.001
Error	1214113	108	11241.79		
Total	4394511	147			

Population density is greatest in moist habitats, especially in association with river valleys, this accounts for the significant association between chameleon abundance and the combined habitat and aspect variables, with low density in habits on ridges and higher densities in valleys associated with rivers. The cause of this has not been identified, but may result from this species laying eggs in the axils of plants and in shallow nests (Gerlach & Gerlach 2001; Heygen & Heygen 2004; Nečas 2004) requiring constantly damp habitats to prevent eggs dehydrating. The population densities recorded here are comparable to those recorded for other *Calumma* species on Madagascar with most sites at 2-15 per hectare (Brady & Griffiths 1999) while *C. tigris* occurs at densities of 2.07 ± 5.00 per hectare in optimal (mid-altitude) habitat. The data collected gives an overall population estimate of $2,055 \pm 620$ individuals.

The absence of chameleons from smaller islands has been suggested to be due to low population densities making small island populations unviable (Gardner 1986). Population densities recorded here would indicate that in order to support a viable population of chameleons an island would have have at least 100 hectares of forested river-valley. This does not exist on any of the smaller islands. The species can be considered Endangered due to habitat deterioration (especially on Mahé and Praslin).

Geckos

Two *Phelsuma* species are present in the granitic islands: *P. astriata* and *P. sundbergi*. The coral islands support endemic subspecies of *P. abbotti*, one subspecies of *P. laticauda* and introduced populations of both the granitic island species. *P. abbotti* is restricted to Aldabra and Assumption (with a different subspecies on Madagascar). *P. laticauda* is also present on Madagascar, in Seychelles it is restricted to Farquhar and Providence atolls. This is a widely introduced *Phelsuma* species (Carretero *et al.* 2006; Ota & Ineich, 0006; Rocha *et al.* 2007) and may be introduced to Seychelles, although Farquhar and Providence are the Seychelles islands closest to Madagascar and most likely to be colonised by this species naturally. Gardner (1986) recorded it from St. Pierre but no evidence could be found of its occurrence there in 2005. These are all

Table 4. Population estimate for chameleons in each habitat on the three islands

Aspect	habitat	Area (ha)			Estimate (individuals per ha)		
		Mahé	Praslin	Silhouette	Mahé	Praslin	Silhouette
Slope	low-altitude	210	100	8	0	18±14	0
	mid-altitude	100	0	60	0	0	1±1
	degraded mid-alt.	300	10	50	0	-	0
	high-altitude	250	0	32	70±33	-	0
	moss	50	0	150	0	-	237±80
Valley	scrub	500	500	73	0	0	0
	low-altitude	500	5	12	0	(0)	(+)
	garden	100	0	0	47±13	-	-
	mid-altitude	100	0	32	0	-	16±50
	degraded mid-alt.	700	0	301	0	-	0
	palm rich mid-alt.	100	750	1088	46±19	248±120	457±120
	high-altitude	650	-	96	345±156	-	240±14
Total	moss	50	-	66	0	-	330±10
					508±221	266±134	1,281±265
					2,055±620		

highly adaptable taxa, being found at high densities (Table 2) in all forest types, although with a strong preference for lowland habitats. *P. sundbergi ladiguensis*, *P. a. abbotti* and *P. abbottii sumptio* can be considered to be Vulnerable due to range restriction, the latter two taxa are likely to be threatened by sea-level rise in the long term. There is a record of the Mahé subspecies *P. a. astriata* being introduced to Praslin where at least one individual coexists with the Praslin subspecies *P. astriata semicarinata* (Van Heygen 2004); hybridization may be a threat to the genetic distinctiveness of the subspecies in the future although more extensive genetic sampling is needed to clarify the distinctiveness of these subspecies and the extent of hybridization.

The Seychelles sucker-tailed gecko *Urocotyledon inexpectata* is a small, cryptic species. Consequently its distribution and population sizes remain little known; there has been only one study of its behaviour (Gerlach 1999). It has been recorded under rocks on Aride island, under bark on North island, in leaf litter accumulations on endemic palms on Mahé, in coconut crowns on Silhouette and in buildings on Mahé and Silhouette. Recorded altitudes range from sea level to 700m. These limited data indicate that the species is widespread and adaptable. It is probable not under significant threat, at present no population estimates have been made and it is considered Least Concern.

Table 5. Status evaluations using IUCN Red List criteria (IUCN 2001). Marine turtle data from the 1980s (Mortimer *et al.* 1996). All *Janetaescincus* populations above 500m are assumed to be *J. braueri* and <500m *J. vesevitzgeraldi*. ‘Extent’ is total range in Seychelles, ‘Area’ is the occupied ground area.

	Islands	Extent (km ²)	Area (km ²)	Population (individuals)	Status
<i>Chelonia mydas</i>	30	86250	-	3,400-4,750	EN A2abd
<i>Eretmochelys imbricata</i>	30	86250	-	1,230-1,740	CR A1bd+2bcd
<i>Dipsosaurus dussumieri</i>	5	86250	159	100,000	VU B2ab(v)
<i>D. hololissa</i>	2	30	1	3 wild	EW
<i>D. arnoldi</i>	1	0	0	1 wild	EW
<i>D. daudini</i>	0	0	0	0	EX
<i>P. castanoides intergrularis</i>	6	2700	<1	150	CR A2bc; B1&2ab(ii,iii)
<i>P. subniger parietalis</i>	6-7	2700	<1	250	CR B1&2ab(ii,iii)
<i>Pelusios seychellensis</i>	?	-	-	-	EX
<i>Lycognathophis seychellensis</i>	6	2700	133	10,038±2,449	EN B1ab(iii)+2ab(iii)
<i>Lampropholis geometricus</i>	4	2700	132	>780±188	EN B1ab(iii)+2ab(iii)
<i>Trachylepis sechellensis</i>	32	2700	233	357,566±105,010	LC
<i>T. wrightii</i>	7	2500	4	376,205±5,409	VU D2
<i>Pamelaescincus gardineri</i>	12	2700	46	170,895±22,059	LC
<i>Janetaescincus braueri</i>	6	1200	12	5,929±119	EN B1ab(iii)+2ab(iii)
<i>J. vesevitzgeraldi</i>	2	2700	16	66,155±2,910	VU B1ab(iii)+2ab(iii)
<i>Cryptoblepharus boutoni</i>	8	40000	200	299,816±86,205	LC
<i>Zonosaurus madagascariensis</i>	3	5	2	6,504	VU D2
<i>Calumma tigris</i>	3	1500	76	3,213	EN B1ab(iii)+2ab(iii)
<i>Ailuroonyx seychellensis</i>	13	2700	74	9,124±670	LC
<i>A. tachyscopaeus</i>	5	2300	57	22,795±1,220	VU D2
<i>A. trachygaster</i>	2	2000	13	3,389±205	VU D2
<i>Hemidactylus mercatorius</i>	5	40000	200	126,900	LC
<i>Phelsuma a. abbotti</i>	4	150	110	269,100	VU D2
<i>P. abbotti sumptio</i>	1	117	117	2,928	VU D2
<i>P. a. astriata</i>	12	1800	190	22,697±1,114	LC
<i>P. astriata semicarinata</i>	16	500	51	26,816±3,862	LC
<i>P. laticauda</i>	3	8	2	?	LC
<i>P. s. sundbergi</i>	9	500	36	3,663±264	VU B1ab(iii)+2ab(iii)
<i>P. sundbergi longinsulae</i>	17	1800	186	19,896±1,703	LC
<i>P. sundbergi ladiguensis</i>	3	100	14	12,751	VU D2
<i>Urocotyledon inexpectatus</i>	11	2300	149	?	LC
<i>Lepidodactylus lugubris</i>	1	2	2	-	?

The house gecko *Hemidactylus mercatoris* is considered to be indigenous to the southern atolls (Cheke 1984) but is introduced in the granitics, currently actively spreading on Mahé (Matyot 2003) and having recently colonised Fregate island (pers. obs.). *H. frenatus* has a scattered distribution on coral islands and *H. brookii* is restricted to Desroches, both probably introduced (Cheke 1984). The identity of '*H. brookii*' needs to be evaluated genetically as African populations have recently been assigned to *H. angulatus* (Carranza & Arnold 2006). *Lepidodactylus lugubris* has only been recorded from Coetivy which has not been surveyed recently and the status and origin of the population are unknown. *Gehyra mutilata* is a widespread introduced species throughout the Seychelles islands, usually found anthropophilically.

It has been suggested that populations or activity patterns of *Ailuronyx* geckos have been reduced by introduced rats (Evans & Evans 1980; Cheke 1984), however Gardner (1986) suggests this is oversimplified and suggests that predation by tenrecs also plays a major role. This was based in part on the erroneous inclusion of Silhouette in a list of islands occupied by tenrecs. The suggestion that arboreal *Ailuronyx* are reduced by terrestrial tenrec predation is not borne out by population density estimates. The populations on Mahé may be more affected by extensive invasion by introduced plants, such as cinnamon *Cinnamomum verum* and guava *Psidium cattleianum*. Forests on Silhouette are stable or recovering (Gerlach 2005b) whilst deterioration continues on Mahé and Praslin.

Future monitoring and conservation

All Seychelles lizards and snakes can be monitored by the methods applied successfully here. Monitoring on Silhouette using transects and focal counts is maintained by the Nature Protection Trust of Seychelles as part of the Silhouette Conservation Project and has been carried out occasionally on other islands; there is a need to establish more regular monitoring. Long term-monitoring and in-depth ecological research will be required to determine conservation needs for individual species but the island comparisons presented above indicate two main aspects that merit further attention: the role of tenrecs on Mahé and Praslin and protection of key sites. These key sites should be protected to ensure the survival of the most important populations, this is already in place for *Trachylepis wrightii* which has substantial populations on several Special Reserves and for the main populations of *Ailuronyx tachyscopaeus*, *A. trachygaster* and *Phelsuma s. sundbergi* which are found within the Praslin National Park, as is the only quantified population of *Lamprophis geometricus*. The main populations of the remaining species are not found within reserve areas; key gaps are Felicite (60% of the *Phelsuma sundbergi ladiguensis* population) and Silhouette islands (43% of *Lycognathophis sechellensis*, 42% of *Janetaescincus veseyfitzgeraldi* and 85% of *J. braueri*). The non-threatened reptile species are all present within existing reserves.

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The meaning of the scientific names of Seychelles dragonflies (Odonata)

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Abstract: The meaning of the scientific names of all Odonata species known from the Seychelles is explained in detail. The basis of many scientific names is ancient Greek or Latin describing characters of the insects or names of important researchers. Understanding the meaning of these names should offer an additional approach for being familiar with these insect species. Additionally, it is a good approach to understand research history of tropical insects - in which the Seychelles play an important role just from the beginning.

Keywords: Odonata, dragonflies, damselflies, scientific name, etymology, Seychelles

Introduction

In the beginning of tropical biology the Indian Ocean islands represented the best explored regions in the world and several species new for science were described from here. In the case of the damselflies and dragonflies (Odonata), the classic works are Drury (1770-1782), Desjardins (1835), Burmeister (1839) and Rambur (1842). Compared with other tropical regions the odonates of the Seychelles are well explored since long times. This knowledge bases mainly on the works of Selys (1869a, 1869b), Wright (1869), Calvert (1892, 1898a), Martin (1895, 1896), Laidlaw (1908), Campion (1913) and Blackman & Pinhey (1967).

The following paper focuses on the meaning of the scientific names of the odonate species known from Seychelles. Understanding the meaning of these names should offer an additional approach for being familiar with these insect species. Additionally, it is a good approach to understand research history - in which the Seychelles islands play an important role from the beginning.

The names and their meaning

The following list includes all species known from of the Seychelles and Aldabra (cf. Blackman & Pinhey 1967). In the transcription of Greek words \bar{e} is used for the letter η (ēta; originally pronounced like -a- in 'rare'), \bar{o} for ω (ōmega; originally pronounced like -aw in 'law'). Accent-bearing vowels are indicated by underlining.

Zygoptera; Damselflies

Megapodagrionidae

Allolestes maclachlani (Selys, 1869); Seychelles Flatwing

Allolestes is a compound name based on *Lestes* (see below), as *Megalestes* - 'big *Lestes*', *Austrolestes* - 'southern *Lestes*', *Indolestes* - '*Lestes* from India') and others. Selys (1869a) chose the Greek morpheme *allos* - 'other, different' as the first part when

he was looking for a name for this endemic Seychelles genus.

Robert McLachlan (1837-1904) was a British biologist, who devoted himself to entomology and engaged himself in the Royal Entomological Society of London. Since 1864 he was the editor of the Entomologist's monthly Magazine. He was a pioneer of the world fauna of Trichoptera and neuropterans, also wrote some 70 odonatological papers. On his recommendation Edward Perceval Wright (see below) sent his odonates collected in the Seychelles islands in 1867 to the Belgian Baron Michel Edmond de Selys-Longchamps, who described several species of that collection.

Lestidae

***Lestes ochraceus* Selys, 1862; Ochre Spreadwing**

Blackman & Pinhey (1967) described *Lestes unicolor aldabrensis* as insular subspecies from Aldabra [Latin *unicolor* - monochromatic]. Following the revision of Pinhey (1980) this form belongs to *L. ochraceus*. *Lestes* [Latin pronunciation] is a Greek word for 'robber'. Why Leach (1815) chose this name he did not say. By many scientists *Lestes* erroneously was treated as feminine in gender, but that is not correct (Davis & Fliedner 1999). Latin *ochraceus* - 'ochre'; Selys (1862) describes the wings of his male specimen as showing a pale ochre tinge. This character is only known from some old males; usually the wings are hyaline (Pinhey 1980). There is no hint that the name refers to the body colour, which Selys describes as brown and yellowish.

Platycnemididae

***Leptocnemis cyanops* (Selys, 1869); Seychelles Featherleg**

Greek *leptos* - 'fine, small/ thin, fine, delicate'; *knēmis* - 'greave'; probably the name points to the fact, that in contrast to the typical Genus of the family, '*Platy-cnemis*' [Greek: 'broad greave'] (Fliedner 1997) in the genus *Leptocnemis* the tibiae are not widened. Greek *kyaneos* - 'dark blue'; *ōps* - 'eye/ face'; Selys (1886) emphasizes in the end of his description: "Notable par ... la face bleu ..." - 'remarkable by its blue face...'.

Coenagrionidae

***Agriocnemis pygmaea* (Rambur, 1842); Wandering Whisp**

Greek *agrimon* means 'living in the fields, wild'; by this genus name Fabricius (1775) comprised all members of the Zygoptera; later on this element was used in compound genus names to indicate that the new genus belongs to the Coenagrionidae (Fliedner 1997). Greek *knēmis* - 'greave' was used first in '*Platycnemis*' [Greek: 'broad greave', an allusion to the widened tibiae in that genus]. But in many names it only means 'Coenagrionid dragonfly'. Primarily, Selys intended the word to be an allusion to *Platycnemis* for genera he supposed to be closely related regardless of widened tibiae. Greek *pygmaios* means 'a fist (*pygmē*) long/ dwarfish'. In ancient Greek tradition the '*Pygmaioi*' were a mythical tribe of dwarfs on the upper Nile, said to have been attacked and destroyed by cranes. This tradition led to the denomination 'Pygmies' for the short people of the Congo basin. Rambur (1842) describes the species as '*minimum*' (Latin: the smallest).

***Ceriagrion glabrum* (Burmeister, 1839); Common Orange**

Latin *cerinus* - ‘waxen, wax coloured’ is a hint on the yellowish colouration of most members of the genus and Greek *agrion* - ‘living in the fields, wild’ has been a genus name by Fabricius (1798) to comprise all damselflies (see above). Latin *glabrum* - ‘without hair, smooth’. In his first description Burmeister (1839) said that this species is very smooth.

***Ichnura senegalensis* (Rambur, 1842); Common Bluetail**

From Greek *ischnos* - ‘thin, lean’; *ura* - ‘tail, in insects: abdomen’; the name refers to a more general feature in damselflies (Fliedner 1997). Latin *senegalensis* - ‘from Senegal’ points to the origin of the specimen, from which the species was described. But already in the first description Rambur (1842) mentioned the Cape, India and Java as places where it can be found.

***Teinobasis alluaudi* (Martin, 1896); Seychelles Fineliner**

Greek *teinō* means ‘I stretch, I extend’. The genus name was created by Kirby (1890) to replace the genus name *Telebasis*, which Selys had given a second time (1877) to a genus different from *Telebasis* Selys, 1865. That name, composed from Greek *tēle* - ‘far off’ and *basis* - ‘base, pediment’, refers to the fact, that in this genus the wings are petioled and therefore the wingbases are far from the thorax.

Charles A. Alluaud (1861-1949) was a French explorer and entomologist (Lhoste 1987) who undertook a scientific expedition to Seychelles in 1892. The French odonatologist René Martin was engaged to publish the collection of odonates gathered by him. Alluaud was president of the Société entomologique de France in 1899 and 1914.

Anisoptera; Dragonflies

Aeshnidae

***Anax ephippiger* (Burmeister, 1839); Vagrant Emperor**

Greek *Anax* - ‘Lord of the House’. The genus might be named from the dominant behaviour of *A. imperator* at water. *Anax imperator* is widespread in Europe and Africa, occurring also on Mauritius and was the only known species when the genus was established. From Greek *ephippion* - ‘saddle’ and Latin *-ger* - ‘bearing’, pointing to a saddle-like blue mark on the second abdominal segment.

***Anax guttatus* Burmeister, 1839; Lesser Green Emperor, Pale-spotted Emperor**

Latin *gutta* - ‘drop’; *-atus* - ‘marked with’, because the abdominal segments bear a double dropshaped mark on both sides (Fliedner 2006).

***Anax tristis* Hagen, 1867; Black Emperor**

Latin *tristis* - ‘sad, mournful’ refers to the mainly black colour of the species as if it was clad for mourning. The description of Hagen (1867a) based on a female specimen with poorly preserved colouration and a darkened body (Fliedner in Suhling & Martens 2007).

***Gynacantha stylata* Martin, 1896; Seychelles Dusk-Hawker**

Greek *gynē* - ‘woman’; *akantha* - ‘thorn, prickle’. The name evokes the 2-4 spines on the ventral side of the 10th abdominal segment of females in this genus (Fliedner 2006). Greek *stylos* - ‘pillar, stile for writing’; l. *-atus* - ‘equipped with’; the name might point to the conspicuous anal appendages, that formerly also were called ‘styli’.

Corduliidae

***Hemicordulia similis* (Rambur, 1842); Madagascar Emerald**

The use of the Greek *hemi-* - ‘half’ is a hint on the relation to the Holarctic genus *Cordulia*. The latter name is based on an adjective derived from Greek *kordylē* - ‘club, cudgel’ and refers to the club-shape of the male’s abdomen. Latin *similis* means ‘similar’; by this name Rambur (1842) pointed on the similarity to *Hemicordulia australiae* described in the same publication on the page before. The animal is described from Mahé as *Hemicordulia delicata* Martin, 1896. Latin *delicatus* means ‘delicate; tender’; in his description Martin (1896) emphasizes the slender abdomen compared with *Hemicordulia similis*. Fraser (1949) placed *H. delicata* as synonym of *H. similis*, however there is some evidence that this very rare form could be a subspecies or species of its own (Dijkstra 2007).

Libellulidae

***Diplacodes lefebvrei* (Rambur, 1842); Black Percher**

Diplac-ōdes - ‘*Diplax* like’. *Diplax* is a synonym of *Sympetrum* long in use; the name is derived from Greek *dīplax* - ‘twofold, double’, referring to the bilobed prothorax’ and *-ōdes* - ‘like a ...’. Kirby (1889) does not refer to *Diplax* directly, but to the genus *Diplacina* Brauer, 1868 [latinized from Greek *dīplak-* (cf. above) and Latin *-inus* - ‘pertaining to ..., related to ...’] already named in reference to *Diplax*.

The species is dedicated to the French entomologist Alexandre Lefebvre (1779-1868), who collected four females of the new species during an expedition in Egypt in 1828-1829 (Fliedner 1997).

***Diplacodes luminans* (Karsch, 1893); Luminous Percher, Barbet Percher**

Latin *luminans* - ‘illuminating, lighting up’. Ferdinand Karsch (1893) reports many shining yellow parts to be on each of his three specimens. As he does not mention the conspicuous red first abdominal segments, his specimens most probably were teneral or in bad condition (Fliedner in Suhling & Martens 2007).

***Diplacodes trivialis* (Rambur, 1842); Blue Percher**

Latin *trivialis* - ‘common, trivial’; there is no explanation of the name in Rambur’s (1842) description. But the species is widespread and common at rice fields and ponds in India and South-East Asia.

***Orthetrum stemmale brachiale wrightii* (Selys, 1869); Strong Skimmer, Wright’s Skimmer**

Orthetrum [Greek *orthos* - ‘straight’; *ētron* - ‘abdomen’] got this name because the

abdomen being straight. Newman (1833) did not know species of different shape. *stemma*le [Greek and Latin *stemma* - ‘wreath, garland’; Latin *-alis* - ‘belonging to, concerning’] has a wreathlike marking on the head, which Calvert (1898b) describes thus: “the frons above the horizontal carina blackish ..., and uniting with a narrow black stripe in front of the vertex and antennae, leaving a yellow spot on the superior surface of the frons surrounded by the black”. Latin *brachiale* means ‘bracelet’; the slightly inflated abdominal base may have induced the name, as if the animals were wearing something like a ring.

The subspecies name *wrightii* is a dedication to the Professor of Botany at Trinity College, Dublin Edward Perceval Wright (1834-1910), an Irish botanist, zoologist and ophthalmic surgeon, who collected the type specimens in Seychelles in 1867. Wright (1869) himself gave a report on his collecting activity, followed by the taxonomic work dealing with his odonate material (Selys 1869a). The taxonomic part was also published in French (Selys 1869b).

***Pantala flavescens* (Fabricius, 1798); Globe Skimmer**

The name *Pantala*, composed of Greek *pant-* - ‘all-’ and *alē* - ‘wandering or roaming without home or hope of rest’ describes the cosmopolitan distribution and vagrant behaviour. The Latin word *flavescens* - ‘becoming yellow, yellowish’ evokes the coloration of females and immature males which is pale orange.

***Rhyothemis semihyalina* (Desjardins, 1832); Phantom Flutterer**

Greek *rhyēnai* - ‘having flown’; and *-themis* ‘law as established by custom’, also name of the Greek goddess of order. Probably Hagen (1867b) when choosing this name was inspired by geology: Rhyolite, whose description was published only a little earlier, is a magmatic stone interspersed with many other minerals, which thus shows many differently coloured irregular patterns. This is also true for the patterns most of the species of this genus show on their wings. The second part of the name is first used as an element in dragonfly names by Hagen (1861), since then it is in use mainly for ‘libellulid genus’. The name *semihyalina* is derived from Latin *semi-* ‘half’ and *hyalinus* - ‘glass, transparent’. Both sexes have the basal half of the hindwing dark with metallic sheen from violet to green, the other half is hyaline.

***Tholymis tillarga* (Fabricius, 1798); Twister**

The name *Tholymis* looks like a Greek word, but it is not. It might be composed of parts of Greek *thōrax*, *lygaios* - ‘shadowed, murky’ and *themis*, as Hagen (1867b) states that in the American species *T. citrina* [Greek: *kitrinos* - ‘of a citron yellow’] the thorax of adult males is dark coloured. The meaning of the name *tillarga* is unknown. All that can be said is that it must be a proper name, as in the first century of its use the word was spelt with a capital T.

***Tramea basilaris* (Palisot de Beauvois, 1817); Keyhole Glider**

Hagen (1849) announced a publication of the genus under the unwieldy denomination *Trapezostigma* [Greek *trapezion* - ‘trapezium’; *stigma* - ‘tattoo, mark’] as a hint to the

trapezoid pterostigma. But in the real description of the genus (Hagen 1861) he had shortened the name to *Tramea*, thus making it handier for use and adding a pun with Latin *trameare* - ‘pass through’ which suits these vagrant species well. Greek *basis* - ‘base, pediment’; Latin *-gris* - ‘concerning...’; the name refers to an amber basal spot with a black mark in each hindwing.

***Tramea limbata* (Desjardins, 1832); Voyaging Glider**

Latin *limbus* - ‘braiding’ and *-atus* - ‘equipped with’ refers to the brown band at the base of the hindwings (Desjardins 1835).

***Zygonyx luctiferus* (Selys, 1869); Dark Cascader**

The genus name *Zygonyx* derives from Greek *zygon* - ‘(inter alia) pair’; *onyx* - ‘claw’. In this genus the claws have a tooth of equal seize to the claws, so that each leg seems to have a pair of claws, not a bifid one (Hagen 1867a). Latin *luctiferus* - ‘bringing about mourning, sad’. The body of the males in the Seychelles endemic species is totally dark (Selys 1869a), to which colour of mourning the scientific name refers.

***Zygomma petiolatum* (Rambur, 1842); Olive Duskdarter, Digny Duskdarter**

The name *Zygomma* is derived from Greek *zeugon* - ‘yoking, bridging’ and *omma* - ‘eye’ and describes well that the head has conspicuous large, broadly contiguous eyes. This feature is characteristic for crepuscular dragonflies such as the genera *Tholymis* and *Gynacantha*. Latin *petiolus* - ‘little foot, little leg, stalk (e.g. of an apple)’ and *-atus* - ‘equipped with’, refers to the extremely slim median part of the abdomen of Rambur’s (1842) sole specimen, lacking the last five segments of the abdomen.

Accentuation of the scientific names

The language of scientific names is deemed to be Latin regardless from which language they actually are derived. Therefore the Latin rules of accentuation have to be followed. In the following list the accent-bearing vowels are underlined as already in the explanations. In Greek words the accentuation often differs from that to be used when they are latinized.

Allolestes maclachlani
Lestes ochraceus
Leptocnemis cyanops
Agriocnemis pygmaea
Ceragrion glabrum
Ischnura senegalensis
Teinobasis alluaudi
Anax ephippiger
Anax guttatus
Anax tristis
Gynacantha stylata
Hemicordulia similis

Diplacodes lefebvrei
Diplacodes luminans
Diplacodes trivialis
Orthetrum stemmale wrightii
Pantala flavescens
Rhyothemis semihyalina
Tholymis tillarga
Tramea basilaris
Tramea limbata
Zygonyx luctiferus
Zygomma petiolatum

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A new species of *Asterropteryx* cheek-spine goby (Pisces, Gobiidae) from the Seychelles islands

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Abstract: *Asterropteryx gubbina* **sp. nov.** is described from Silhouette island, Seychelles. It is close to the widespread Indo-Pacific species *A. semipunctata* but differs in (1) having a dark spot and vertical bar on the caudal peduncle, terminated by a white area, (2) lacking a filamentous spine in the first dorsal fin and (3) having 12 second dorsal spines.

Key words: *Asterropteryx gubbina*, Gobiidae, new species, Seychelles

The cheek-spine goby genus *Asterropteryx* Rüppell, 1828 contains 8 species of small (less than 50mm) gobies from marine lagoons and reefs of the Indo-Pacific region. They are diagnosed by having at least one posteriorly directed spine on the posterior margin of the preopercle, cycloid or ctenoides scales on the cheek and operculum, no cutaneous ridge on dorsal midline of nape, dorsal fin spines usually VI+I, 10, anal fin rays I, 9; dorsal spines flexible; vertebrae 10+16=26; dorsal pterygiophores 3/II II I I 0; 2 anal fin pterygiophores anterior to first haemal spine; single epural; 6-7 transverse rows of sensory papillae below eye; cephalic sensory canal with pores B', C (single), D (single), E, F, G, H', K', L', M', N and O' (Shibukawa & Suzuki 2002, 2007). These characters are all found in other gobiids and no synapomorphies of *Asterropteryx* have been identified (Shibukawa & Suzuki 2002).

The genus can be divided into two groups (Shibukawa & Suzuki 2002, 2007): the “*spinosa* complex” (*A. spinosa*, *A. bipunctata*, *A. senoui* and *A. ovata*) and the “*semipunctata* complex” (*A. semipunctata*, *A. ensifera*, *A. striata* and *A. atripes*). These can be distinguished by the *semipunctata* complex having almost entirely separate pelvic fins, with only a rudimentary connecting membrane between the bases and no frenum; anterior-most caudal vertebra lacking a parapophysis; enlarged haemal arches on anterior most caudal vertebrae; preopercular spines restricted to between pores N and O'; embedded throat and ventral surface of gill membrane scales; cephalic sensory papilla row d broadly interrupted; some pairs of sensory papillae behind chin; blue spots on body.

On 5th December 2007 a distinctive *Asterropteryx* species was located in shallow lagoon waters on Silhouette island, Seychelles. Three further specimens were collected on 6-8th December and these specimens were compared to described species and recognised as a distinct species. This species is described below.

Methods

Counts and measurements follow (Shibukawa & Suzuki 2002, 2007). Scale counts were taken under dissecting microscope at x10 magnification. Cephalic sensory canals and papillae observed under a dissecting microscope at x10 and x40 magnification.

Pores and canals were labelled after Shibukawa & Suzuki (2002,2007).

Institutional abbreviations: NPTS - Nature Protection Trust of Seychelles; UMZC - University Museum of Zoology, Cambridge

Comparative material of the two most similar members of the *Asterropteryx semipunctata* group were examined: *A. semipunctata* (NPTS un-numbered) and *A. ensifera* (UMZC F5935, 3 syntypes of *Asterropteryx monacanthus* Regan, 1908: 240).

***Asterropteryx gubbina* sp. nov.** (Fig. 1, 2, 3a)

Holotype. Male 13.9+3.21mm, UMZC F2008.1.1, south La Passe lagoon, Silhouette island, Seychelles, 4°29'03"S 55°15'09"E, 6th December, collected J. & R. Gerlach

Paratype. Female 12.9+2.13mm, UMZC F2008.1.2, 4°29'03"S 55°15'09"E, south La Passe lagoon, Silhouette island, Seychelles, 6th December, collected J. & R. Gerlach

Paratypes. Female 12.7+2.05mm, NPTS Cp2008.1, south La Passe lagoon, Silhouette island, Seychelles, 4°29'03"S 55°15'09"E, 5th December, collected J. & R. Gerlach; Male, damaged specimen (anterior half only), NPTS Cp2008.2, south La Passe lagoon, Silhouette island, Seychelles, 4°29'03"S 55°15'09"E, 7th December, collected J. & R. Gerlach

Diagnosis. *Asterropteryx gubbina* is distinguished from all other *Asterropteryx* species in having a dark spot and vertical bar on the caudal peduncle, terminated by a white area. It differs from *A. semipunctata* in lacking a filamentous spine in the first dorsal fin. It differs from *A. ensifera* in these characters and in having (1) at least 2 cheek spines (rather than 1) and (2) 12 first dorsal fin spines (rather than 9-11); from *A. atripes* and *A. striata* in having (1) no black lateral band, (2) a rounded caudal fin, and (3) topmost cheek spine below pore N.

Description. Dorsal fin spines VI+I 12; anal fin rays I 11; pectoral fin rays 12-16; pelvic fin rays I, 4-5, the innermost may be unbranched; branched caudal fin rays 6+6; upper unbranched caudal fin rays 2-5, unsegmented; lower unbranched caudal fin rays 4-6 unsegmented; longitudinal scale rows 24-25; transverse scale rows counted from origin of anal fin upward and forward to base of 1st dorsal fin 8.5; predorsal scales 8.

Proportional measurements given in Table 1. Head and body rather compressed, typical for *Asterropteryx*. Eye moderately large, its diameter equal to snout length. Interorbital space narrow, with less than pupil diameter. Mouth terminal, oblique, forming an angle of about 35° with body axis. Lower jaw slightly projecting beyond upper jaw. Posterior end of jaws extending to below anterior margin of pupil. Anterior nostril a short tube without skin flap. Posterior nostril a pore, closer to anterior margin of eye than to anterior nostril. Tongue rounded or nearly truncate, anterior tip free from floor of mouth. Lower lip interrupted at symphysis. Mental flap on chin absent. 2-4 short posteriorly directed spines on posterior margin of preopercle, uppermost one situated just behind and below sensory canal pore N; all preopercular spines similar in length, uppermost one slightly longer than others. Gill opening moderate in size,

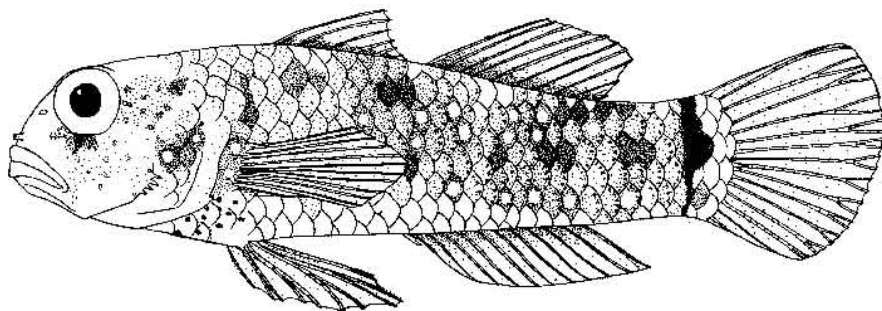


Fig. 1. *Asterropteryx gubbina* holotype. Scale bar 5mm. Note dorsal fin rays are finely divided, this is not distinguishable in the figure.

Table 1. *Asterropteryx gubbina* morphometrics

	Holotype	Paratype	Paratype	Paratype
	Male	Female	Males	Females
Standard length (mm)	13.9	12.9	-	12.7
% of standard length				
Head length	24.5	17.9	17.0	22.5
Snout length	5.4	4.9	5.5	5.4
Length of longest cheek spine	0.8	0.7	0.7	0.7
Length of second longest cheek spine	0.7	0.7	0.7	0.7
Eye diameter	9.2	10.0	9.8	9.3
Interorbital width	1.2	1.1	0.9	0.9
Jaw length	6.1	6.9	6.5	6.9
Nape width	11.1	11.0	10.8	10.6
Head width	12.6	12.0	12.6	11.8
Head depth	22.7	23.0	22.9	22.6
Body depth	24.2	26.9	23.9	23.8
Body width	20.1	22.0	19.8	20.4
Predorsal length	38.2	39.4	38.0	39.1
Prepelvic length	36.1	29.8	35.5	29.8
Preanal length	60.3	57.4	-	58.7
Caudal peduncle length	23.7	16.5	-	16.0
Caudal peduncle depth	10.0	16.0	-	19.5
Length of D1 base	13.0	15.1	14.2	14.3
Length of first spine of D1	11.3	9.0	10.1	10.0
Length of second spine of D1	13.0	13.3	19.0	18.8
Length of third spine of D1	15.1	9.0	10.1	16.5
Length of fourth spine of D1	13.0	9.0	13.0	11.0
Length of D2 base	24.8	21.5	22.2	29.3
Length of spine of D2	15.1	11.2	10.1	10.2
Length of first segmented ray of D2	4.9	8.4	8.8	5.5
Length of longest segmented ray of D2	4.9	8.5	8.9	5.1
Length of first segmented ray of A	11.9	8.0	10.1	10.8
Length of longest segmented ray of A	12.7	10.0	10.8	11.7
P1 length	29.9	29.9	30.1	29.8
P2 length	24.8	25.0	22.5	23.0
Length of spine of P2	12.8	6.0	7.2	10.9
Length of fourth segmented ray of P2	14.8	21.0	13.5	12.9
Length of fifth segmented ray of P2	13.4	15.4	12.2	11.9
C length	19.6	23.3	-	21.5
% of head length				
Snout length	20.0	16.5	23.4	22.1
Eye diameter	36.0	33.3	29.9	30.2
Interorbital width	8.0	11.1	9.1	8.9
Jaw length	28.0	28.8	25.2	26.3
% of caudal peduncle length				
Caudal peduncle depth	44.1	55.1	-	49.0

lower edge extending anteriorly beyond pectoral fin base, reaching a vertical line at posterior margin of preopercle. Gill membrane attached to isthmus. No fleshy papilla-like projection on lateral margin of lateral wing of cleithrum. 1st dorsal lacking filamentous spines; 2nd spine is longest and reaches to base of 2nd dorsal. All segmented pelvic and caudal fin rays branched. Second dorsal fin higher than first, rays 1-8 uniform in length, 9-12 less than half the length of preceding rays. Pectoral fin rounded to slightly pointed, 6th ray longest, extending posteriorly to a vertical from base of anal fin. Pectoral fin rays unbranched. Pelvic fin not united at base, joined by only a rudimentary membrane; no pelvic frenum, 5th ray longest, tip reaching to base of anal fin; 5th ray 80% of fourth; all rays of pelvic fin branched. Caudal fin rounded.

Scales on head and body ctenoid with 16 cteni, except for slightly embedded cycloid scales on the anterior half of cheek, ventral surface of gill membrane, throat, nape around predorsal midline, pectoral fin base, prepelvic region and anterior half of abdomen. Snout, chin, lips, ventral surface of lower jaws and interorbital region naked. Teeth in jaws simple, conical; upper and lower jaws with about 4 rows of teeth anteriorly, narrowing to a single row posteriorly. Teeth in outermost row largest; no prominent canine-like teeth on jaws. No vomerine or palatine teeth.

Patterns of cephalic sensory systems shown in Fig. 3. Oculoscaphular canal with pores B', C (single), D (single), E, F, G, H', K' and L'; preopercular canal with N and O'. Right and left sides of oculoscaphular canal fused medially between pores C and D. Five short transverse rows of sensory papillae (1, 2, 3, 4/5 and 6) below eye. At least one longitudinal row of sensory papillae behind chin.

Colour in life. Dark phase: head and body dark brown to black, iris dark brown; alternate rows of body scales (rows 5 and 6) with a bluish white spot in centre of scales, blue spots also present on operculum and pectoral base. All fins infuscated with dark grey spots, most concentrated on base of dorsals. Caudal peduncle with a central black spot, crossed by a vertical dark bar which is wide above the spot, narrow below. Peduncle white posterior to the black band.



Fig. 2. Live *Asterropteryx gubbina*, photographed wild at La Passe, Silhouette 8th December 2007.

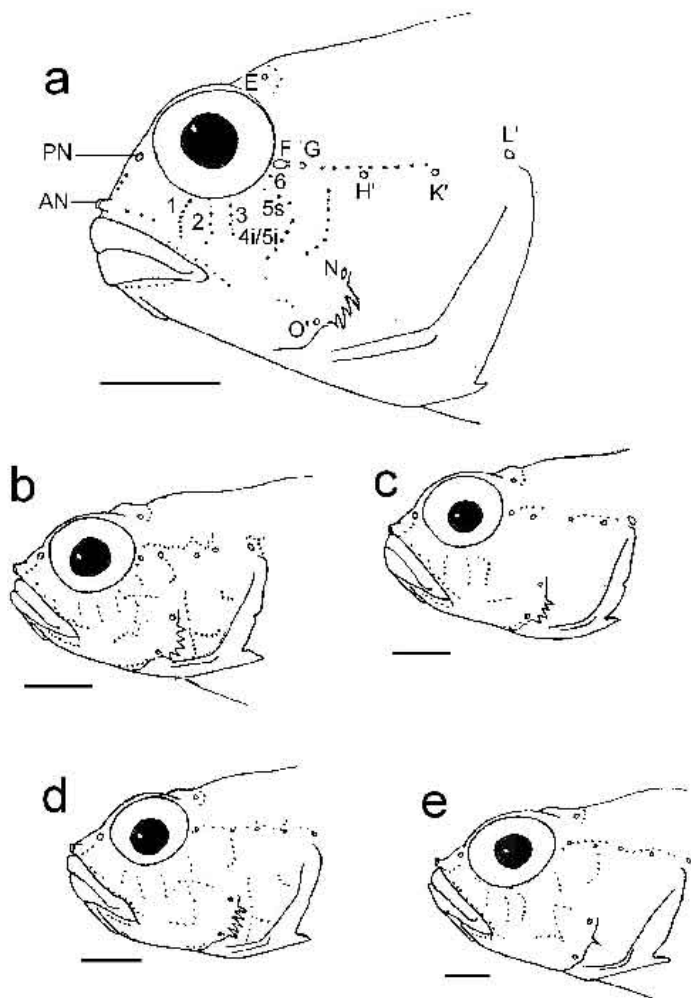


Fig. 3. Cephalic pore arrangement in *Asterropteryx semipunctata* group. a) *A. gubbina*; b) *A. atripes*; c) *A. semipunctata*; d) *A. striata*; e) *A. ensifera*. Scale 1mm. Dots represent sensory papillae (papillae rows numbered), open circles represent sensory canal pores (lettered). AN – anterior nostril, PN – posterior nostril.

Pale phase: dorsum off-white to pale grey-brown, cheeks and throat pale reddish-brown; three short dark reddish brown bars radiating from antero-ventral margin of eye; iris pale reddish-brown with white spots. Small dark spots on pre-pelvic region; large pale blue spots on operculum (2), pectoral base (2) and body (3 irregular rows of 5-6 spots on scale rows 5 and 6). Light reddish-brown patches on dorsum, may form 6 vertical bars. Pale scales with distinct dark chromatophores on posterior margin. Six white patches on dorsum between base of 1st dorsal and caudal. Caudal peduncle with central black spot, vertical dark bar reaching to spot and sometimes to underside, white posterior to

the black band. Caudal and pectoral fins hyaline, other fins with light brown bases.

Sexual dimorphism. Urogenital papilla distinct, long, narrow and pointed in males; female papilla short, broad, rounded or flattened. No sexual dimorphism in colouration. Both sexes lack filamentous dorsal spines, in males the 2nd or 3rd spine of the first dorsal reaches the base of the 2nd dorsal, in females no spines reach the 2nd dorsal.

Etymology. gubbina from ‘gubbins’ 16th century English for small pieces of fish.

Ecological and geographical distribution. All preserved specimens described above and 5 live individuals studied and released (8-9th December 2007) were collected from coral rubble in a lagoon at 1m depth. Subsequently one individual was observed in similar habitat in a depression on the reef flat.

Discussion

Asterropteryx gubbina belongs to the “*semipunctata* complex” of Shibukawa & Suzuki (2002) which is diagnosed by having unfused pelvic fins without a frenum, 1-10 cheek spines, throat scaled, operculum with approximately 4 rows of scales, two rows of papillae beneath chin, interrupted row of cephalic papillae, blue spots and no caudal black spot. Within this group it most closely resembles *A. ensifera* and *A. semipunctata*. Both *A. gubbina* and *A. ensifera* lack a filamentous spine in the first dorsal fin, in *A. ensifera* the longest spine is the 4th, in *A. gubbina* it is the 2nd or 3rd. *A. gubbina* has more rays in the second dorsal (12) than either *A. ensifera* (10) or *A. semipunctata* (9-11) and has more cheek spines than *A. ensifera* (2-4 compared to 1). It also differs from *A. semipunctata* in lacking a filamentous spine in the first dorsal. The colouration of the caudal peduncle appears to be distinct from all other *Asterropteryx* in the possession of a contrasting vertical black bar with a central spot and a terminal white area. This pattern is reputed to occur in small *A. semipunctata* but is not described in literature and we have not found it in specimens; a review of variation in *A. semipunctata* is in progress.

Key to species of the *Asterropteryx semipunctata* complex:

1. Black lateral band in pale phase individuals. Caudal truncate. Topmost cheek spine level with N. Hovering habit. Pacific only 2.
No black lateral band. Caudal rounded. Topmost cheek spine below pore N. Bottom-dwelling. Indo-Pacific 3.
2. 3rd spine of first dorsal reaches to caudal fin. No black spots on dorsum, iris reddish, pelvic fin black. West Pacific *A. aripes*
No filamentous dorsal spine, 4th spine may reach 2nd dorsal. Black spots on dorsum, iris white ventrally, pelvic fin translucent. Pacific. *A. striata*
3. First dorsal fin spine with filament reaching C. Second dorsal with 10-11 rays. No black spot and bar on tail, no with end to peduncle. Indo-Pacific. 4.
No filamentous spines on dorsal, 2nd spine may reach second dorsal. Second dorsal with 12 rays. Black spot and vertical bar on tail, followed by white. Seychelles. *A. gubbina*
4. 1 cheek spine. A black lateral band sometimes present. *A. ensifera*
2-9 cheek spines. No black lateral band. *A. semipunctata*

To date 115 species of Gobiidae have been recorded from Seychelles, including only two *Asterropteryx* species: *A. semipunctata* (Playfair 1867; Peters 1878; Möbius & Peters 1883; Smith 1958, 1963) and *A. ensifera* (Regan 1908 as *A. monacanthus*; Smith 1963). Smith (1965) considered *A. semipunctata* to be “common” and *A. ensifera* to be “rare”, both species have been recorded at a wide range of depths. *A. semipunctata* is reputed to favour “dirty water” (Hoese 1991) and in Seychelles specimens have been collected around Mahé (north-east and east coasts), Anonyme, Souris and Aldabra, all coastal reef flats and mangroves. *A. ensifera* has been collected at “Amirantes, 30 fathoms” (island not specified - Regan 1908). *A. gubbina* has only been recorded in clear water in the coastal lagoon and in pools on the reef-flat at depths of less than 1m.

Asterropteryx gubbina was found in coral rubble in the in-shore lagoon in December 2007. This habitat was shared with the tropical sand goby *Favonigobius reichei*, the green-bubble goby *Eviota prasina* and *Valenciennea sexguttata*. Littoral rocky fringes of this habitat were also occupied by the blennies *Istiblennius andamensis* and *I. impudens*. In March 2008 seasonal sand movement resulted in most of this rubble being covered by sand. *A. gubbina* were observed to move to areas of lower turbidity and by April 2008 were restricted to silt-free pools within the reef-flat. Captive *A. gubbina* were observed to feed on small *Thalamita* sp. crabs and one individual was eaten by an immature *F. reichei*. Courtship display was seen in captive gobies in December 2007 and a 1cm juvenile observed in April 2008.

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NOTES

Dipteran fly parasitising the Seychelles stick insect *Carausius seychellensis* (Bolivar, 1895)

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During a two weeks expedition on the Seychelles central island Praslin in December 2004 (Pawlowski & Krämer 2005a, b) the habitat and feeding plant of the Seychelles stick insect, *Carausius seychellensis* (Bolivar, 1895) was investigated. *Carausius seychellensis* were mostly inactive during the day, being attached to plants. During the night, stick insects were active, feeding on ferns. Although, this fern plant was rather common on Praslin, the stick insect *Carausius seychellensis* was rather rarely distributed within these areas of fern plants. In total, only three adulte females, two adult males and one juvenile were found sitting on the upper and the under side of theses plants. One female with a damage on one of the six legs (which makes it distinguishable from the other specimen detected) was found twice within two days sitting at the same fern, displaying only little movement (probably during the night). Another female was attacked by two dipterans flies (Ceratopogonidae) parasitising on the joint of the leg of the stick insect and sucking haemolymph liquid (Fig. 1).

The two flies were about 1-3 mm in size and dark red to black in colour. The other stick insects observed did not show any ectoparasites. Even the locusts found on Praslin Island did not show any parasitic flies. Although it is well known that insects such as stick insects and locusts were hosts of various invertebrate endoparasites such as nematoda and nematomorpha (see Storch & Welsch 1991, 1994), parasitising flies on stick insects has not been detected so far. Even during later expeditions in November/December 2007 on the islands of Mahé and Praslin, only few stick insects of the various native species could be found across the two islands, excluding the area of the Morne



Fig. 1. Parasitising fly on the angle of the front leg of the Seychelles stick insect *Carausius seychellensis*.

Seychellois National Park (Mahé) where they are rather common. However, none of the stick insects displayed these parasitising flies at that time. Although a wasp attack on *Carausius seychellensis* has been described in the past (Hardling & Thompson 2002), this could not be seen as a parasitical behaviour rather than a predator behaviour. Thus, based on our observations, it is not very likely that these flies are real threats to the Seychelles stick insect *Carausius seychellensis* on the islands of Praslin or Mahe.

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Seafaring behaviour in House Crows *Corvus splendens* – a precursor to ship-assisted dispersal?

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Indian house crows *Corvus splendens* have colonised many parts of the world, largely through travelling voluntarily on ships without human assistance. Meininger *et al.* (1984) and Ryall (1994, 1995, 2002) have charted their spread; Lever (2005) summarised the present distribution. Given their origin in the sub-continent, the Indian Ocean has been the main theatre of the spread; continental coastal ports have seen most invasions, but they have also reached the oceanic islands. Mauritius was first reached around 1900 (Carié 1904), the birds already ‘multiplying’ around the harbour in Port Louis by 1904 (Carié 1904, *contra* the usually stated date of 1910, e.g. Long 1981, Cheke 1987, Lever 2005, following Meinertzhagen 1912). After the original population was all but wiped out by a powerful cyclone in 1945, the island was recolonised in 1950 (Rountree *et al.* 1952, Cheke 1987). Birds were first seen in the Seychelles in 1970, with further arrivals in 1977 (Ryall 1994); the incipient colony was controlled but more birds have subsequently turned up (Skerrett *et al.* 2001, Ryall 2002). Crows appeared in Réunion in 2004 (Salamolard 2004, Cheke & Hume 2007, Chakouat *passim*); although one of a pair was shot, others are still present.

The house crow is the only landbird that regularly and deliberately hitches rides on ships, unusual behaviour that is potentially dangerous for the birds. These crows are persistent and abundant scavengers in all human habitations in their natural range, including ports, where exploring moored ships is simply an extension of their normal activities. Use of ships in harbour has been cited as an explanation for the birds’

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ship-borne spread (Madge & Burn 2001) - but why stay with a ship when it sails?

A possible answer to this may lie in the remarkable behaviour seen in house crows in Sri Lanka. In June 2005, holidaying in the fishing port of Negumbo on Sri Lanka's west coast north of Colombo, I observed these crows behaving in a very unexpected way. Every morning dozens of sailing catamarans, the local fishing vessels, leave the port for the open sea, returning at or before dusk with their catch. While I was there the boats would leave Negumbo and sail northwards roughly parallel to the coast, gradually moving further from shore. As they passed the hotel strip north of the old town, crows in ones and twos or small groups would leave the settlements and coconut plantations of the coast and fly directly out to sea to catch up with the catamarans. Birds would fly directly to boats 1-2km offshore, apparently riding with the catamarans all day out of sight of land, before being seen to fly back to land as the boats returned in late afternoon. This behaviour was almost confined to house crows, only one jungle crow *C.macrorhynchos* (much less numerous) being seen to fly out to sea.

House crows are extraordinarily abundant on Sri Lanka's west coast, and in an area without gulls *Larus* spp., have learnt to exploit, not only on shore but also at sea, the ample supply of unwanted fish and offal that gulls consume at higher latitudes. Once used to riding on sea-going vessels, crows might easily alight on ships that were heading for the open sea, then becoming as-it-were trapped until the ship reached its next landfall. Indeed the first two birds recorded in Durban were seen "flying in from the sea", presumably off a ship, in 1972 (Ryall 1994). Given the clearly well-established behaviour in western Sri Lanka, it is notable that of the four colonisations by self-introducing birds where the ship's original port is known, two (Somalia & Mauritius, both in 1950) started their journeys in Colombo (Lever 2005). In addition birds have travelled to Australia from Colombo on at least three occasions in 1926-1959, although no colonisation resulted (Meininger *et al.* 1984). The other successful examples are the 1970 arrival in Seychelles of birds on a ship originating in Bombay, and a secondary spread from Aden to Socotra in c.1996, Ryall 2002).

As the birds' seafaring behaviour is very conspicuous, it is odd that it has apparently not been recorded in the literature. None of the standard works on Indian and Sri Lankan birds consulted (Legge 1880, Oates 1889, Dewar 1925, Whistler 1949, Henry 1971, Ali & Ripley 1983, Grimmett *et al.* 1999) mention riding on boats, and Iris Darnton (1975), an old Ceylon hand describing Negumbo's fishery and its attendant crows in 1947, only mentioned birds scavenging on shore. There is no allusion to this behaviour in Ryall's papers already cited or his website, in Madge & Burn's (2001) corvid monograph, nor in Lever's (2005) review of bird introductions; Chris Ryall (*in litt.*) admits to not having encountered it. This would seem to suggest that the behaviour has arisen recently, but House Crows have been spreading by voluntary ship-assisted passage (in addition to deliberate introductions) since at least the 1890s. Once the regular use of steamships significantly reduced journey times between Indian Ocean ports, birds would have been able to survive crossings on which they might previously have starved. Ryall (2002) commented that the faster ships in recent years will have increasingly facilitated longer journeys, including to the Americas. Feare & Mungroo (1990) pointed out that expanding urbanisation and consequent availability of rubbish

tips at destination ports has facilitated establishment in new areas. Some colonies first recorded in the mid-late 20th century are suspected to have been present unnoticed for years or even decades (Lever 2005).

Seafaring behaviour may however be older. There is an ancient tradition that Indian and Singhalese mariners carried crows on ocean-going vessels to help them find land. Bisoodoyal (1968) quoted the following passage from the *Indian Review* of August 1961 [grammar unadjusted]:

“ It was an ingenious practice among the early Indians to carry with them trained birds of strong wings in their voyages to guide them to shores in case of difficulty to determine lands and directions This instinct particularly of crows, which are a conspicuous species of birds of India, is a common knowledge. There are references to shore-finding birds, crows, in the *Digha Nikaya* and the *Baveru jataka* [both old Buddhist texts -ASC] as having been carried by seafarers in their trading expeditions.”

Anon (1821) mentioned that this use of crows is “said to have been practiced by the people of Ceylon in early times”. This practice may have originally arisen from crows accustomed to fishing boats accidentally alighting on ocean-going vessels, and thus being carried far out to sea before flying off toward the first land eventually sighted. Similar use of corvids (ravens *C. corax*) for land-finding was reportedly used by medieval Viking mariners and recorded in Icelandic sagas (Anon 1821, La Fay 1972). Pre-modern transport, deliberate or accidental, does not however seem to have resulted in any overseas colonisations, as none of these predate the 1840s (Aden) and some early ones (Aden itself, and also Zanzibar, 1890s; Malaya, 1903) were the result of deliberate releases (Lever 2005). In addition to possible accidental long-distance transport by birds used to fish offal as suggested here, Skerrett *et al.* (2001) claimed (without giving any source) that the crows’ spread has been assisted by “Indian sailors often encouraging birds to remain on board by feeding them”.

Whether travelling by accident or encouraged by sailors, it is clear that house crows are amongst the hardest of invasive species to exclude. While import and export restrictions can theoretically control unwanted exotics that are traded or carried by people, it is a different matter for species that have a behavioural pattern that facilitates self-dispersal. Since birds will leave for land well before a ship docks (e.g. the Durban case cited above), control ideally needs to be done on-board while the ship is in the open sea, which, given the myriad ships and crews of different origins, is unlikely to be widely effective. This leaves as the only feasible method prompt action once birds have landed. Fortunately, as scavengers, they tend to gravitate towards rubbish tips and abattoirs, where they can be trapped or shot. The Seychelles are particularly vulnerable to re-invasion, as house crows are now abundant not only in India but also in Mauritius and East and South African ports. Contingency control measures are likely to remain necessary on a long-term basis.

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Additional 18th century records of endemic Seychelles fauna

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While going through 18th century manuscripts from Philibert Commerson in Paris to extract data for Mascarene animals, I also came across material from Seychelles - representing species not formally described for many decades after Commerson

received them and had them drawn. The drawings, by Commerson's artist Paul Jossigny, are held in the archives of the Bibliothèque de Muséum in Paris (Laissus 1974), as part of MS 282 (2). This is a series of portfolios with drawings of specimens from Bougainville's expedition around the world, and from Madagascar and Indian Ocean islands done after Commerson left the expedition. He was then based in Mauritius from 1768 until his death in March 1773 (Oliver 1909, Monnier *et al.* 1994).

Jossigny was a meticulous artist, and his drawings of vertebrates and large invertebrates are easily identifiable even (as often) when they are not annotated by Commerson. Amongst the drawings are accurate renderings of the giant tenebrionid beetle *Polisopipus herculaneus*, the Seychelles chameleon *Calumna tigris*, and two depictions of Seychelles endemic snakes (*Boaedon geometricus* or *Lycognathophis seychellensis*) which I was not able to identify on the spot. Apart from being labelled as from the Seychelles, the reptile drawings are not annotated, and the beetle does not even have the locality noted. In addition to these endemic animals, there are two drawings of a white-tailed tropic-bird *Phaethon lepturus* labelled as from Seychelles, and a brown noddy *Anous stolidus* that the context suggests was also from the islands. Published explorers' accounts of the period (Gerlach 1995) reported the seabirds, and a snake on Praslin, but not the chameleon or the beetle. As I was on a different quest, and the museum's charge for reproducing these archives is substantial, I did not request copies - so this note is primarily to draw attention to the presence of Seychelles material in the Commerson archive. There may be further items (particularly invertebrates) that I missed, and there are also written descriptions by Commerson, mostly in Latin, which might contain items from Seychelles, though I did not notice any when looking for Mascarene material.

Commerson did not visit Seychelles himself (Ly-Tio-Fane 1978), so the specimens must have been collected for him by one of the several expeditions from Mauritius that visited the Seychelles during 1768-1771 (Lionnet 1972). The drawings are unlikely to be later than 1771 as Jossigny remained in Réunion after Commerson's visit there that year, returning to his job as the island's second engineer (Ly-Tio-Fane 1978). Commerson also acquired plant specimens from the Seychelles (62 species, Laissus 1974), including the first material of the Coco-de-mer *Lodoicea maldivica*, controversially written up by his other artist Pierre Sonnerat (1776), who disingenuously implied having visited the Seychelles himself (he only passed nearby offshore). The Coco-de-mer material was collected by botanically-minded astronomer 'Abbé' Alexis Rochon in 1769 (Lionnet 1972, Ly-Tio-Fane 1978, Monnier *et al.* 1993), who, as a scientist, and friend of Commerson and Pierre Poivre (civil governor of Mauritius), may also have brought back the other specimens. Commerson's material remained unpublished in the Paris archives, and the animals mentioned above were not formally described until much later when new material became available. The beetle was eventually described in 1848 (Gerlach *et al.* 1997), the snakes in 1837 (Nussbaum 1984) and the chameleon in 1820 (Bourgat & Domergue 1971).

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The risk to other Indian Ocean islands of invasive species on Diego Garcia

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In addition to the political issues around the presence of the American base on Diego Garcia, there are biological implications which extend beyond that island to the rest of the Chagos and other islands of the Indian Ocean, perhaps most especially the Seychelles. Since their occupation of Diego Garcia, the Americans have, by accident or design, introduced a number of highly invasive animals, with the risk of doing great harm if they spread to other islands. Flights come in to Diego Garcia regularly from Guam and the main place used by US service personal for rest & recreation is Singapore. Guam is home to several ecologically disastrous species, and Singapore is a major centre of the pet trade, the main way in which inappropriate species are spread around the world.

One of the world's worst tropical pest species is already abundant on Diego Garcia - the notorious Cane Toad *Bufo marinus* that is causing such problems for native wildlife and even domestic pets in Australia (Lever 2001, 2003). Apparently released

sometime between 1980 and 1989 (Lever 2003), they were reported as already 'very common' in 1996 (Barnett & Emms 1997, 1998), as they still are (Gordon Rodda, *in litt.*). These South American toads are very large (up to 1 kg) voracious carnivores that compete with native animals for food and have seriously toxic glands in their skin - basically anything that tries to eat them dies - and naïve cats, dogs, marsupials etc. that have never met a lethal amphibian fall victim to its poison. They produce huge numbers of tiny tadpoles and can thus multiply incredibly fast in the right environment - such as Diego Garcia. They have been generally introduced to sugar-producing countries to control pests in the cane fields, but although they (sometimes) lead to some agricultural benefit, the downsides are so bad that they are included as one of the only three amphibians in the official list of the world's 100 worst invasive alien species (Lowe *et al.* 2004). It would be a disaster if they were to reach other Indian Ocean islands. Attempts were made to introduce them for biological control in Mauritius in the 1930s and 1950s (Cheke & Hume 2008), but they unexpectedly and unusually failed. They might not fail again there, and their probable effects on the unique herpetofauna and invertebrates of the granitic Seychelles do not bear thinking about, nor the consequences if they were to reach Madagascar. No one seems to know how or why they were released on Diego Garcia (Lever 2003).

Guam is infamous amongst ecologists for having had nearly all its native vertebrates wiped out by a single invasive species, the Brown Tree Snake *Boiga irregularis* from the New Guinea area, which slipped in with the US military from the Admiralty Islands in the late 1940s (Fritz & Rodda 1998, Lever 2003). It is nocturnal and so sneaky that it took decades for biologists to discover the cause of the declines, and by then it was too late for most of the birds, lizards and bats affected. This snake will insinuate itself into all sorts of potential hiding places, including crates, luggage and planes. So far the US military, stung by the disaster of their own making in Guam, have so far been vigilant enough to keep it out of Diego Garcia. Back in the 1980s when one was found in a hangar, it escaped into a nearby marsh and the area was dowsed in petrol and fired to make sure it was killed! (Ted Morris, pers. comm.). Another was found and killed on a ship at anchor before it reached land (Fritts *et al.* 1999, no date given), and 'about 5 years ago' one was seen but escaped (Gordon Rodda *in litt.*). However other snakes (even a python) do turn up on planes (Gordon Rodda *in litt.*), and the risk of a pregnant female tree snake arriving unseen is all too real. The Brown Tree Snake is by far the worst of the only two reptiles listed amongst the 100 worst invasive species (Lowe *et al.* 2004), and its establishment on Indian Ocean islands would be the worst ecological disaster since rats arrived on the Mascarenes in the 1600s.

The 'Bloodsucker', Indian Garden Lizard or Crested Tree Lizard *Calotes versicolor* has arrived in Diego Garcia within the last few years (date uncertain; Nik Cole & Gordon Rodda, *in litt.*), apparently from Singapore, and is now widespread on the atoll. This is not in itself a risk to other Indian Ocean islands since the damage has already been done - the species has been present in Réunion and Mauritius for over a century (Vinson & Vinson 1969), and more recently been introduced from the latter to Rodrigues (ca.1986, Cheke & Hume 2008) and to the granitic Seychelles (1982 & 2003, Matyot 2004). It is assumed to be nefarious to native invertebrates, but details

NOTES

are few (Maureemootoo *et al.* 2003, Matyot 2004); in Rodrigues it is regarded as a pest for sitting on commercial hives and picking off the bees (Jauze 1998), so would be best kept off the northern Chagos if people are to return there. However the fact that this versatile animal made it from Singapore (where it is itself a recent arrival: early 1980s - Lever 2003), shows that there is a risk of other, more damaging, animals arriving from the same direction. Despite quite severe official quarantine arrangements, I don't imagine US military personnel are above attempting to smuggle pets in to live up their enforced exile on Diego Garcia, and there may even be some legal pets there ? Mauritius, Réunion and the Seychelles have strict rules about importing live animals, but unwanted faunal immigrants keep arriving - partly through escaped/released pets (originally traded legally), partly through people smuggling them in (mainly lizards), especially to Réunion (Cheke & Hume 2008).

The widespread house gecko *Gehyra mutilata* has also arrived recently on Diego Garcia (Nik Cole & Gordon Rodda *in litt.*), but again this has been around inhabited islands of the Indian Ocean for a very long time (Cheke 1984, Cheke & Hume 2008), and is generally scarce away from buildings, so is low-risk to native fauna.

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